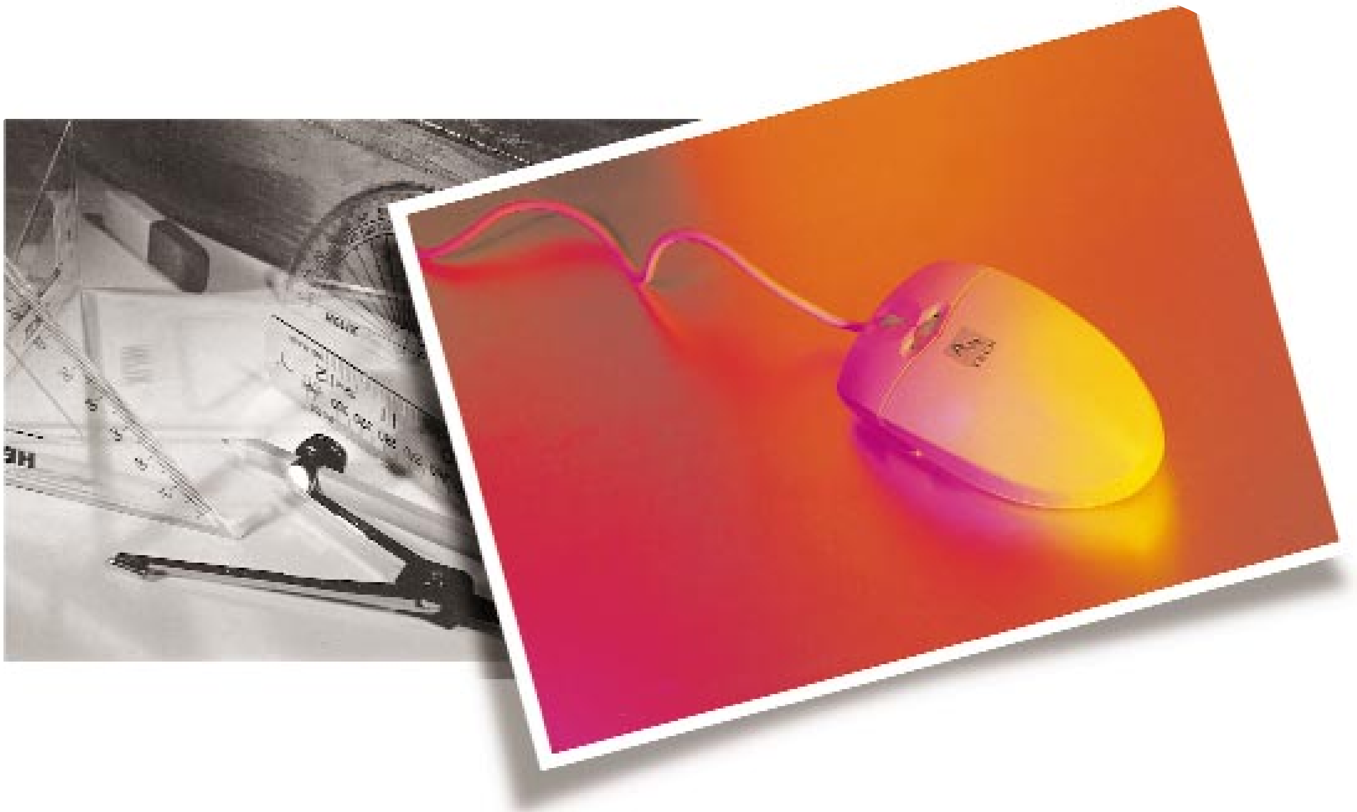
Engineered for Perfection



CAD/CAM systems have been in vogue for quite some time now, but the latest developments promise to take industrial and product design to a new plane altogether

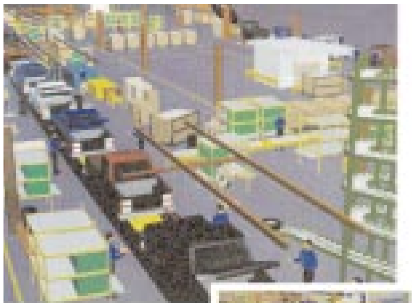
The human brain is the best design tool ever. And yet, the transformation from thought to metal can be an arduous process. Over the past few years however, Computer Aided Design (CAD) tools have made things considerably easier for industrial product designers.

Almost anything from that sinuous Ferrari to the latest Silicon Graphics flatscreen monitor—is likely to have the CAD professional's indelible mark on it.

The tribulations of design

Whenever a new product—from electronic consumer products and automobiles to ships, aeroplanes and bicycles—is designed, many people are inevitably involved. The product that comes out of a factory is not the stylist/designer's idea alone. It is a compromise between the different opinions of designers, materials scientists, ergonomists, technical specialists and styling gurus. And these are just the purely functional people involved in the design of a product. Amongst others, there are vendors, marketing specialists, finance, and accountants to contend with.

Each of these functionaries has their own concerns. A materials specialist at



Manufacturers in the US use CAD for complete factory automation

Yamaha, whose main concerns, while designing a sportbike chassis would be light weight and strength, might want to use carbon-fibre composites extensively. The accountant, whose main aim would be to save money, will try to make sure that the designers make do with aluminium. The stylist might want a skimpy, swooping fairing and low-set handlebars, while the ergonomist might argue in favour of the opposite.

And thus, manufacturing wars are fought endlessly in the product-design departments of companies across the world.

CAD—the universal language

As design progressed through routine trials and tribulations, expensive clay mock-ups had to be prepared repeatedly, which not only required great modelling expertise, but also used up a large amount of time and money.

Enter CAD/CAM, and ka-boom!

Computer aided design and manufacturing has, entirely changed the design process. Engineers everywhere are adopting 3D visualisation, which involves the preparation of life-like CG representations of real-world objects. Applications like AutoCAD, DesignCAD, CorelCAD and many others, allow the user to create 3D models that are accurate to a fraction of a millimetre. More advanced CAD/CAM solutions allow the creation of interactive 3D objects (for a given set of parameters, the CG object accurately simulates the behaviour of its real-life equivalent), which can be animated to move like the real thing.

Automobile manufacturers have taken the lead in adopting pervasive CAD/CAM, which actually has wider connotations than most people would believe. Use of clay models and wind-tunnel testing, which was such an integral part of automotive design as late as the mid-90s, is already archaic. Companies are now using computer-generated 3D models which are tested in a virtual wind-tunnel to calculate real, physical values of structural stress, CD (coefficient-of-drag), chassis rigidity, high-speed flex and so on. BMW, for example, has used an animation product (now available in the market, by the name of Oxygen SketchMap) to convert simple two-dimensional sketches into 3D models, which can be viewed, animated and stress-tested, all in real-time immersive 3D environments. Developed in conjunction with Coventry University (UK) and Prosolvia Clarus, this software application allowed BMW to develop and distribute many different versions of a basic design, with typical Teutonic efficiency, bypassing the need to build even a single physical (clay) model.

Lockheed Martin, those revered British designers/manufacturers of fighter aircraft, use comprehensive interactive visualisation in a virtual product development environment. Working on a variety of advanced aircrafts for the 'Joint Strike

THE BIKE THAT CAD BUILT

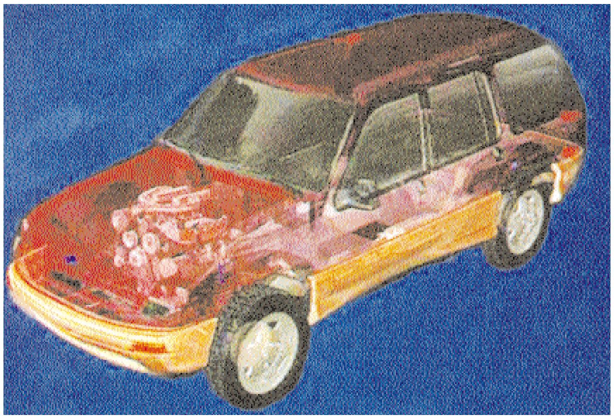
In the hi-profile world of designer-label CAD, money does all the talking. Custom-made products, using high-end CAD/CAM applications to maximise design performance, can cost the earth. Usually, people who use exotic, one-off designs are professional car/motorcycle/boat racing teams, but even the humble bicycle is catching up. A highly optimised, carbon-fibre (an extremely light-weight, yet very strong material) framed, professional racing bicycle (the kind you might see in Tour de France) can cost up to Rupees 10 lakhs! (The design moulds, which are thrown away after being used just once, can cost up to Rupees 4 lakhs.)

In the US, Utah-based Mark Enders is trying his best to change this outrageous equation. His company, Composite Arts and Science, has, with the intelligent use of CAD, finite element analysis, and advanced composite materials, managed to really cut down on building costs for high-performance racing bicycles. Enders, an artist with carbon-fibre and epoxy, engineers the frame of his bike so that the bottom bracket area does not flex laterally, and therefore more of the energy from the riders legs goes into [achieving] forward motion .

For designing, Enders uses DesignCAD to create an accurate 2-dimensional illustration of the bike and then imports the file into Algor Superdraw, to create the basic 3D model of the bike. After determining the basic structure and calculating the carbon-fibre placement, the next step is to carry out the finite element analysis. This is a process where all the elements of a virtual model are broken down into small, uniform elements, and stress-tested for their reaction to simulated real-world conditions. The frame is tested for stiffness and flex-characteristics under high-stress situations. Depending on the construction-material properties and defined loads, the CAM software computes, and solves the stress equations. Such automated structural analyses are essential when using composite carbon materials, as they are anisotropic the material strength changes with the direction in which it is measured (in the case of carbon fibre, the strength depends on the direction in which the piles are laid).

Enders endeavours have proved that

Design Engineers



CAD applications allow testing of a design before manufacture

Fighter' program (which involved the design of an entire new family of fighter aircrafts for the US Air Force and the British Royal Navy), Lockheed Martin not only optimised the design processes, they also discovered new ways of evaluating and calibrating the working interfaces between various existing subsystems, at the conceptual stage itself. 3D visualisation allows teams, working on different sub-systems of the aircraft, to view others' work in the early stages, calculate its impact on their own functional areas, and carry out modifications accordingly.

Multi-site collaborative engineering allowed LM to reportedly, halve their manufacturing costs, and cut down on their maintenance costs by 30 percent in 1998, as compared to 1997.

A higher purpose

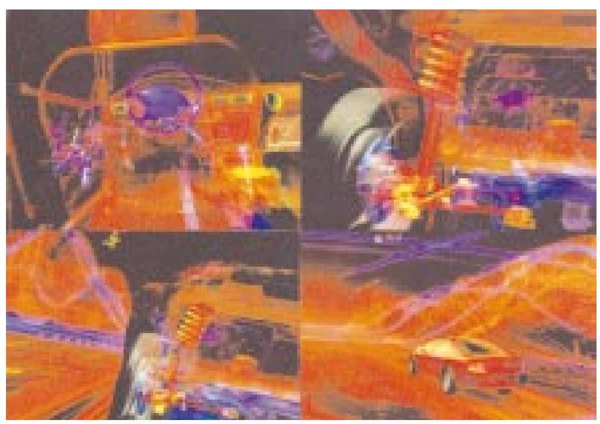
As you might expect, CAD professionals need more than the odd copy of AutoCAD or 3D StudioMAX. Specialist tools are available, which far exceed the capabilities of conventional CAD packages.

AutoStudio, for example, is one such application, meant specifically for automotive design. A NURBS-based (Non Uniform Rational B-Splines) surface modeller from the Alias Wavefront stable, it allows the creation of complex curvatures while maintaining the curvature continuity between two different/overlapping surfaces—a feature important in automotive design. The software maintains a 'construction history' for all objects and this can be modified at any point.

When changes are made to any modelling parameters, the history is updated automatically. The application has excellent rendering capabilities, and can be used for mechanism design analysis, analysis of ergonomics and automated assembly simulation.

CATIA Surface Design (developed jointly by IBM and Dassault) is also an application- specific CAD package which works with bezier-type surfaces to create skins and closed 3-dimensional volumes. To make modifications, a user can just select one face of a 3D object, and the application selects the remaining faces automatically. The product can also compute geometrical and inertial object characteristics, which can help in structural, and finite-element analysis.

Other CAD packages, with similar professional-level capabilities are also available. Surf Modeler from ICEM Technologies, Euclid Styler from Matra Datavision, ProDESIGNER from Parametric Technologies and I-DEAS Master Surfacing from SDRC-Ideas—all can be used for professional product design. There are also reverse-engineering CAD tools, which are sometimes used to improve (or simply analyse) older products designed in the pre-CAD era. Surfacer 7.0 from Imageware is one such tool. It allows the creation of CAD data for objects that have none. The application allows the construction of complex surfaces from scanned and digitised point data allowing a designer to bring into a CAD/CAM environment, a part which may not have any prior CAD 'history' at all. Engineers can then make these older product designs work in conjunction with newer ones.



Data driven design

Apart from its primary design and engineering-related functions, CAD is now also being used to provide advanced manufacturing solutions. PDM—Product Data Management—is the new buzzword. PDM systems are used to track all product information related to design and engineering. This kind of a system displays the relationship between multiple subassemblies of a product, in the form of graphical hierarchy depicted by a tree-like structure similar to the one we see in, for example, Windows Explorer.

Now, 3D CAD models are being used to make product data management much more visual, and simple. In this case, the conventional 2-dimensional graphical interface is replaced by a 3D model, and all engineering data is represented by 3-dimensional renderings of each part. Such a 3D graphical interface not only makes it easy for people to access product information, it also allows workers to view product structure, along with the product geometry.

Engineering Animation Inc's VisFly application, integrated with SDRC's Metaphase PDM system, is already used extensively at the Ford Motor Company. EAI's VisNetwork program manages all visual data generated by VisFly (the 3D product visualiser), and VisMockUp (a digital prototyping application) and integrates this information with SQL-compliant relational databases. The program displays components regardless of the CAD platform they were created in and allows users to manage product information for up to one million parts, with the ability to analyse them concurrently and interactively. Other interactive visualisation tools like Division's dV/Reality, allow users to interact with large 3D virtual assemblies in real-time. These tools also allow 'intelligent' behaviour—the virtual models behave like their real-life equivalents.

However, there are still some issues to contend with. PDM virtual mockups are meant to let users view product assemblies quickly, and thus they are based on faceted representations of the actual CAD models, which are intensively data driven. Whenever product geometry changes, the PDM model has to be changed as well, which can mean a huge amount of additional work when it comes to working with products with tens of thousands of assemblies and sub-assemblies.

The challenge ahead

CAD has taken over as the one of the most important aspects of product design, but there is still a long way to go. The greatest problem seems to be power, versus ease of use. The more powerful and capable CAD systems are, the more difficult they are to use. Gerald Garavuso, a senior manger for Design Practices at the Xerox Corporation, is of the opinion that software developers should create 'layered' user-interfaces, which novices can use at a much more basic level using a basic set of commands and menus. This would allow applications to retain a modicum of simplicity for those who need it, while professionals can still take advantage of an advanced array of functions, which they require.

Interoperability is another problem. With dozens of CAD packages in the market, there is a lack of standardisation in file formats, and exchanging data becomes difficult.

STEP (Standard for The Exchange of Product model data) did make efforts in this direction, but not much seems to have come of it. Large corporations also want to share CAD models over the Internet, and everybody wants to get into 'collaborative engineering'.

All this sounds good, but with tens, maybe even hundreds of MBs of data (as a result of huge polygon counts, a very large number of sub-assemblies, bitmapped texture files, and animation information) contained in complex product models, bandwidth issues pose a big impediment.

Nevertheless, professionals can look forward to using advanced CAD/CAM systems more extensively than ever before. Pervasive digitisation of all product data will see the rise of real-time collaborative engineering over networks. PDM, and use of 3D visualisation tools, in conjunction with animation applications, shall let engineers design better. And yes, you can look forward to even more beautiful Ferraris, faster fighter jets, and better-looking display systems.

SAMEER KUMAR

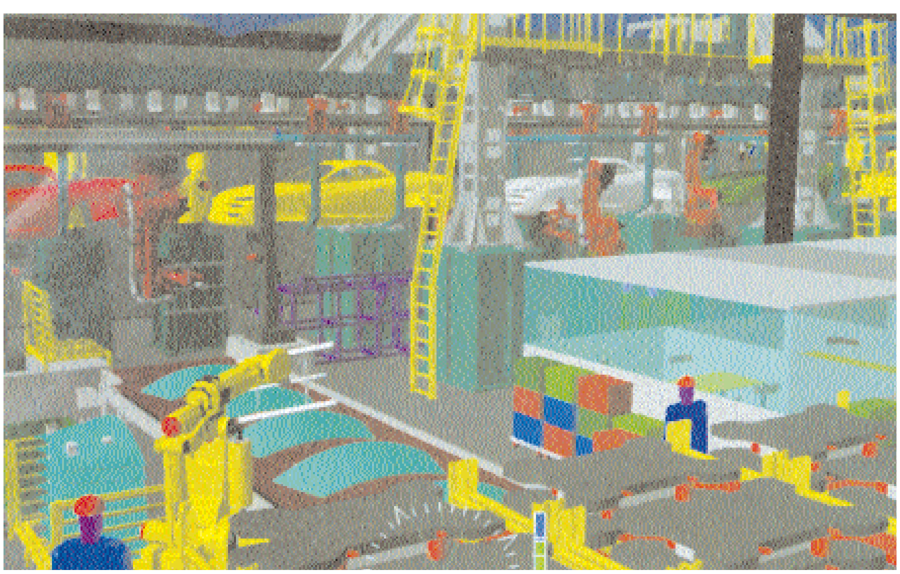
FACTORIES IN NEVER-LAND

Competing in the Internet era can be tough, and manufacturers look for every scrap of competitive edge they can get. Attention-spans get shorter, and given consumers penchant to switch loyalties at the drop of an advertising campaign, manufacturing has become a dangerous game. Despite ups and downs, productions must go on or a manufacturing plant cannot earn its keep. CAD/CAM, by reducing the number of steps involved in the design process, addressed these issues to some extent, but now manufacturers want to take the game to the next level.

Factory simulation technology! Yes, product simulation is old hat manufacturers are now using factory simulation tools for planning and optimising manufacturing processes. A completely computer-generated digital factory, complete with simulation software for robots, conveyors, work-cells, and shop-floors, enables prospective manufacturers to envision the entire production process from design and assembly, to packaging and shipping. This allows close scrutiny of all sub-processes that go on in a factory, and possible bottlenecks can be identified and rooted out before they ever become a reality. It also helps manufacturers to prepare for retooling, and goes a long way towards minimising downtime.

Dassault Systems DMAPS (Digital Manufacturing Process Systems), and EAI s FactoryCAD are two packages which allow production visualisation, planning and management. Again, automobile manufacturers, who are at the forefront of CAD program usage also, are leading the way.

In the US, Chrysler used a factory CAD application called CCPlant, for its Toledo Jeep factory, and its Project KJ was designed and simulated in 3D, before it was actually built. In the future, Chrysler hopes to reduce the tooling-up time for a new model by at least 12 months, by



All production processes can be tested for efficency in a computer-generated virtual factory

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