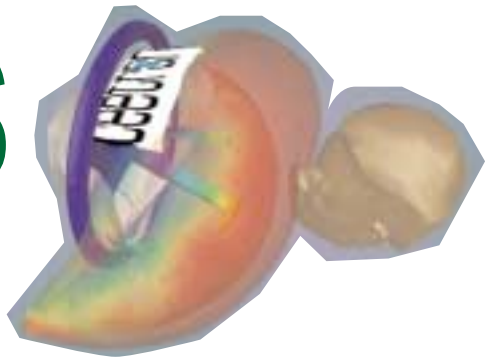
Give us the tools



Simulation for safety: Software from AC&E gets to grips with CFD analysis for a vehicle's airbag

Analysis packages make product design a lot simpler, but they can be two-edged tools. *John Pullin* puts the spotlight on FEA, CFD and CAD

If you want to get ahead in engineering software, get on to the product developer's machine. That seems to be the message as more and more engineering programs align themselves with CAD systems and offer themselves up as part of the design engineer's armoury.

There is much sense in expanding the range of tools and rules that design engineers can apply to verify and refine their ideas. If competitiveness is to do with getting products right first time, and shortening the new product introduction process, then giving your designers kit that'll tell them if they are making sense or not seems a good idea.

But in one area of engineering, at least, there is some unease about this. Finite element analysis (FEA) covers a wide range of programs in testing and simulation where products can be analysed for important factors such as stress, strain, heat, fluid flows and other properties. FEA methods have been around for 30 years or so, and most engineering graduates these days have at least nodding acquaintance with the tools from their courses. But this is not expertise.

Until recently, there wasn't a problem. "Ten or more years ago FEA was a specialised task performed by a relatively small number of experts using unfriendly software," says John Horspool, principal engineer with landing systems maker Messier Dowty. "This has been turned almost completely on its head with large numbers of users with questionable credentials driving analyses on overly friendly software."

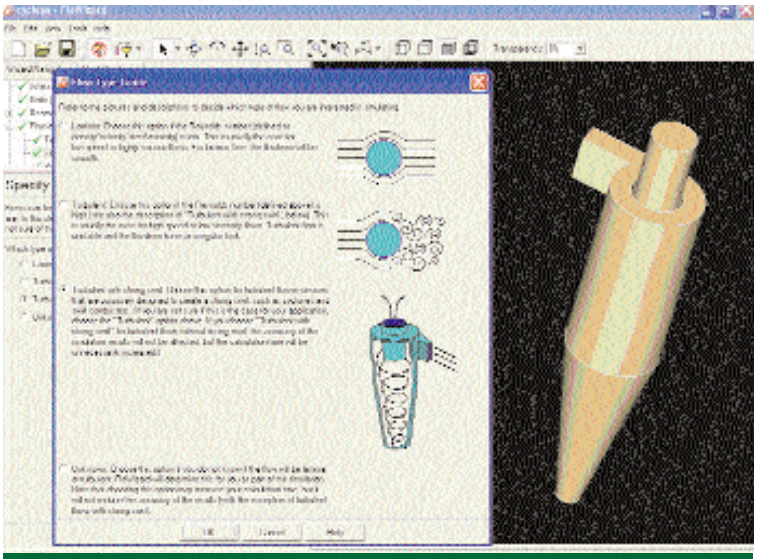
The difficulty, the critics say, is the link between computer-aided design and FEA, which has brought previously difficult tasks within the orbit of product designers. Some well-known CAD packages now come with an analysis package as a standard add-on. Well-known software firms in specific sectors such as computational fluid dynamics (CFD) have developed "lite" versions of their standard ranges or "wizards" to speed familiarisation and to use on standard tasks, with direct links to CAD packages and CAD data.

There are some strong benefits from these moves. There is no doubt, for instance, that an awful lot more analysis and simulation is now being done, and many products that previously wouldn't have been tested are now being done almost routinely. Faster development, fewer prototypes, quicker decision-making: all of these are benefits from widening access to FEA.

And there's no doubt either that the more accessible analysis and simulation packages are powerful and more than competent to do the work. "Just about any FEA software will deliver excellent results," says Horspool. "But only if driven correctly."

Bob Johnson of training company DAMT says that one of the problems of aligning FEA so closely with CAD is that design software produces perfect results: "You get component geometry that fits the bill perfectly. It carries the load, it interfaces with its surroundings, all wall thicknesses and dimensions are valid, it has finite volume, pins and dowels line up, it can be manufactured." But, if geometry can be perfected, the same cannot be said of stress analysis: "One can never produce a perfect FEA," says Johnson.

Horspool has some sympathy with designers: "With complex solids displayed on the screen you have a 'what you see is what you get' scenario. It's easy to understand how a stress contour plot will be viewed in much the same light."



Familiarisation package: Flowizard from Fluent talks the user through CFD principles

Illusion of perfection

But, says Johnson, there are many areas where the appearance of perfection is deceptive. CAD models have features removed for easy meshing; the mesh doesn't follow the geometry because of element smoothing operations; constraints are approximated because the component is part of an assembly; and many others.

"The biggest problem," says Horspool, "is the incorrect and unrealistic application of boundary conditions to models. Probably the vast majority tend to apply loads at one end of their models and fix the other, thus reducing all models to a cantilever. Simply reverse the clamped and loaded ends and you see a completely different set of results."

Horspool says that experienced stress engineers have

used free-body force diagrams in hand calculations for decades. "Any true FEA engineer knows that clamped supports produce false stress concentrations, but how many designers know this?"

Among the suppliers of the more complex systems dealing with non-linear properties, such as those used in CFD, there is wide agreement that there is a potential issue here that they need to address. "The question is how do we do it when things can be done just at the push of a button," says Anthony Mosquera, manager of consulting services for specialist analysis and simulation company Applied Computing and Engineering (AC&E). "My own view on the fluids side is that it's difficult in any analysis to know you've got the right answer. The only way to be confident is to validate and compare against the real model."

Danger zones

Mosquera says that there is pressure to try to make operation of analysis systems easier and to move them into the design area, "but without knowledge of the physics it's potentially dangerous". He believes, though, that a distinction needs to be made between analysis where the accuracy of the results is critical and those where it is merely indicating a trend.

Chris Carey from the CFD group Fluent says that some customers have been putting analysis tools in the hands of their design engineers for many years as part of the design process. "Some do it by customising the CFD tools to work on specific problems and others get their engineers to use heavyweight tools under expert guidance."

Fluent has taken a two-pronged approach to what Carey says is the reality, which is that customers increasingly want CFD as part of their standard product design armoury. One of these has been to develop Flowizard: "This is designed to automate the process through a wizard and through other automated tools to make it acceptable to design engineers." Key to this is to make the process easier without making the results any the less valid, and to make the analysis compatible with more sophisticated Fluent CFD tools. The use, says Carey, is primarily in "getting the basic geometry right".

A second approach is to customise CFD tools so that complex operations that need to be done for a particular customer or product series can be built into the software, reducing the dangers of inexperience. But, Carey adds, there are limits to this approach. "For instance, if you wanted to design part of a combustion system you might start off by doing isothermal analysis as a first step to get the flows balanced correctly. But later on you might want to model the combustion itself, and then you'd need to call in a specialist."

It's knowing where this borderline is between the routine and the expert that is the difficulty, says Brian Miller of Wilde FEA, which is celebrating 25 years in the business this year. Miller sees the FEA and CFD market dividing into companies that deliberately go for the high-end complex users and those heading for the desks of the product designers. The key to the latter, he says, is training and guidance.

But Miller doesn't believe that these systems are going to stop at design verification: "What we're now saying is: 'Don't wait until you've done a 3D model because you'll have put in detail that you may not want'. We're saying that if you design from scratch you should start with concept modelling using FEA and do the FEA before you get to a 3D model."

What this won't get around, all agree, is the need for expertise in verification of designs later on. "But the fact is," says Carey at Fluent, "that there is a shortage of CFD expertise and the analysts should concentrate on the things that really need them."

The trend towards putting ever more complex tools on to the product designer's system looks unstoppable. But it doesn't have to be a problem if users are aware that, alongside the opportunities it opens up, there may also be potential pitfalls.

Make modelling measure up to reality

It's not just in the FEA area that product designers are getting new kit on their machines. Ian Bell of virtual instrumentation company National Instruments (NI) says: "We have been working our way up the design chain, working with others or by ourselves to allow designers to make measurements earlier in the design process."

The reasoning is similar to the ideas leading FEA on to designers' desks: "If you get to a physical prototype, then discover a flaw, it's all cost," says Bell. NI's LabView technology provides an interface to the physical world so designers can build real measurements into their test regimes. The company has linked with CAD giant SolidWorks to bring real data into the modelling process, with real world measurements sitting alongside the data derived from 3D models and working with the Cosmos analysis package that comes bundled into the CAD system.

"This is very much a focus area for us," says Bell. "It's all about early integration of real world data into the design process."

Model program: LabView helps to build real measurements into test regimes

"Ten or more years ago FEA was a specialised task performed by a relatively small number of experts using unfriendly software" John Horspool