CADfix boosts productivity for Holset

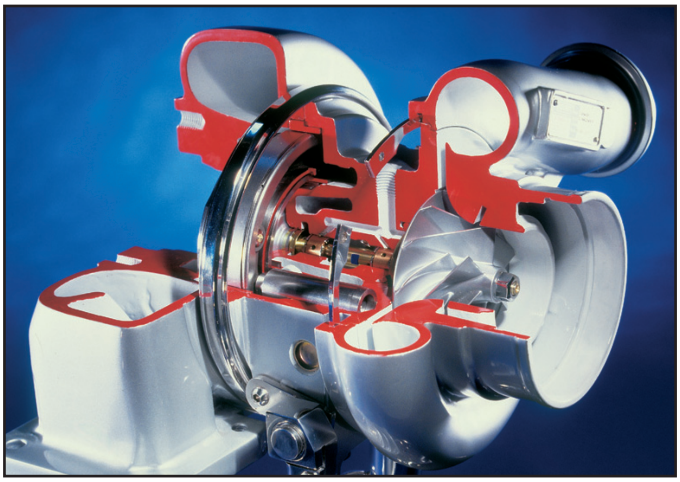
The turbocharger surely falls into the 'Why didn't I think of that?' category of inventions. Its principle – using the pressure of engine exhaust fumes to boost performance by driving more oxygen into the cylinders – makes so much sense that you begin to wonder why they aren't fitted to all engines. In fact, in one class of engines, they are.

Diesel engines – those for heavy duty trucks and machinery at any rate – rely on turbochargers for their very existence. They boost power, broaden torque curves and increase fuel efficiency to such an extent that without turbos, diesel engines would not be able to deliver the 'workhorse' output demanded of them.

Holset Engineering

One of the biggest names in turbochargers, Huddersfield based Holset is at the cutting edge of research and development in this field. A wholly owned subsidiary of Cummins Engines for more than 25 years and an OEM supplier to other major European manufacturers, its turbochargers are used in engines throughout the world. With 2,500 employees worldwide turning out around 750,000 turbochargers a year, Holset has a turnover of over £200million.

Fundamental to Holset's success has been its continued emphasis on research and development. Although the company's turbochargers are manufactured at production facilities throughout the world, they continue to be designed and engineered in Huddersfield, where the company was founded in the early 1950s. Mike Eastwood is Applied Mechanics Manager at Holset Huddersfield. "Working very closely with engine manufacturers allows us to keep track on all the latest developments and helps us in our constant search for new innovations," he explains.



Variable geometry turbocharger

The need for analysis

As the turbochargers it produces are essential to the useful functioning of the engines in which they are fitted, the pressure on Holset to be able to guarantee their performance and longevity is enormous. The only way to do this is by knowing the exact physical state of each turbocharger component while the engine is running. As it is not practical to wait until a new turbocharger has been manufactured before measurements can be made (and some vital internal components will be impossible to measure in any case) it will come as no surprise to learn that Holset relies heavily on finite element analysis (FEA) and computational fluid dynamics (CFD) to predict performance early in the design process.

Mike Eastwood: "We seldom have too much physical room to play with so over-designing in the interests of a margin of error is not really an option. It is vital that we know as much as possible about every component's performance under operating conditions." And because such conditions are among the more extreme faced by design engineers – typically pressure ratios of 5:1 and temperatures of up to 800ºC – it is easy to see why predictions are not left to hand calculation.

Data exchange bottleneck

Holset's designers use Pro/Engineer as their core CAD tool, making full use of its parametric assembly modelling capabilities. Each turbocharger component then has to be analysed in Ansys, while the performance as a whole is determined in a proprietary CFD package. The transition from a Pro/Engineer CAD component model to the Ansys FE mesh required for both flavours of analysis, however, is far from straightforward, and represented a significant stumbling block for Holset.

Without a direct translator between Pro/E and Ansys, Mike's team had little option but to make do with the unreliable medium of IGES files. These would rarely do the job satisfactorily and would invariably mean extra work for somebody.

"Up until about 18 months ago we basically had two options when our first stab at IGES transfer failed," explains Mike. "We could go back to the designer and ask them to change the way the model was created inside Pro/Engineer, or we could try to make the changes ourselves using the limited geometry tools within Ansys. Either way, this would be a time consuming process and of course there was a danger that we would compromise design intent."

Things have moved on a lot since then. The introduction of a Pro/Engineer input tool within Ansys helped to some extent but the real breakthrough came with the arrival of CADfix. "Even with the Ansys import there were very few cases when we achieved a direct transfer first time round," says Mike. "More often than not further work would be required, and we would often have to spend as much as a whole working day preparing models for meshing when we should have spent that time interpreting analysis results."

CADfix bridges the gap

The data transfer problems that Mike and his team were encountering are not uncommon in today's solid and surface modelling engineering culture. Anyone who has had to reuse geometry created in a modern CAD system in some other software package – whether it be another modeller or, as in this case, a downstream analysis application – is almost certain to have encountered an interoperability issue at some level or another. Reasons for this stem from the inherent complexity of defining surface geometry in space and inconsistencies in the way different systems go about such definition, particularly in the matter of tolerances. It is not unusual for a gap to appear between two 'adjacent' surfaces from one modeller, for instance, simply because the second system does not consider them a close enough fit.

CADfix, developed by Cambridge-based FEGS, has been designed specifically to address this kind of problem. It offers a host of automated and interactive tools for first diagnosing and then repairing illegal or suspicious areas of geometry. The result is that fully defined solid models – and even assemblies – can be derived very quickly from even the messiest of IGES files.

Productivity gains

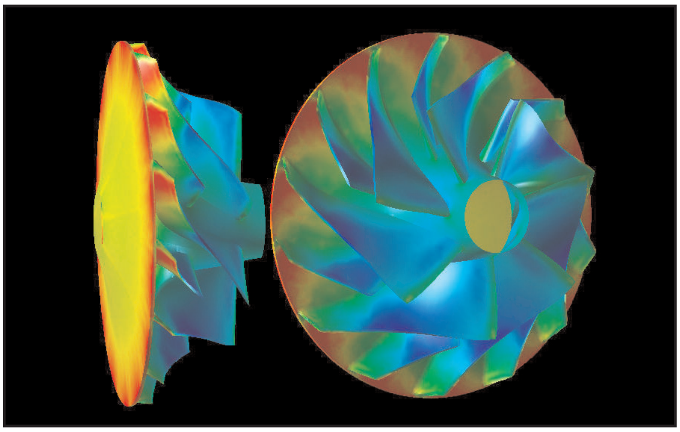
For Holset the introduction of CADfix has meant nothing short of a revolution in terms of productivity. Typically, data reworking that would take an entire day is now completed in a single hour. "I would estimate that CADfix plays a vital role in at least two thirds of the FEA jobs we undertake," says Mike. "More models than before are now coming through the direct interface because we have looked at ways of configuring the output from Pro/E, but we still turn to CADfix more often than not."

Richard Evans, who is in charge of the CFD programme at Holset, is equally enthusiastic. "We have to create FE meshes of internal airways, effectively the inverse of Pro/E models," he explains. "These are very complex shapes often with regions that taper away to nothing, and such regions are traditionally very difficult to mesh. CADfix handles this situation perfectly and quite simply we couldn't manage without it."

The boost in productivity means that Holset's engineers can spend more time performing analyses and interpreting their results. This not only means that the final products are better engineered – they have after all been subject to far more analysis – it also allows more time for R&D.

Variable geometry turbocharger

Perhaps the most obvious example of Holset's recent ongoing development programme – and certainly one where CADfix had an important part to play – is in the company's patented variable geometry turbocharger (VGT) technology.



Compressor wheel CFD results

Turbocharger technology does have certain limitations, particularly at higher performance levels: as air pressure rises, the operating range (and therefore the usable engine speed) is reduced. This leads to the use of more and more ratios in the gearbox and more gear-changing work for the driver. Turbo-lag is also increasingly obvious when operating at higher pressures.

Holset's ingenious solution to this problem is a turbocharger whose geometry can be changed in situ. An electronic control system governs the configuration of a surprisingly simple assembly with few moving parts – an important factor in such a hostile environment.

The effect of altering the size of the turbine according to the demands of the engine is that vehicle acceleration can be improved at low speeds, turbo-lag can be significantly reduced and 'engine braking' power can be increased. Furthermore, VGTs can be used in smaller engines resulting in lower fuel consumption, fewer gear shifts and lower, more controllable emission levels. Finally, the ability to adjust the VGT's characteristics throughout an engine's life means that performance can be maintained for longer and that emission levels in older engines can be more carefully regulated.

"I suppose it is fitting that CADfix has helped us with our variable geometry technology," says Mike Eastwood. "Our renewed efficiency should mean that we have more time for this kind of development work and we can continue to build on our reputation for innovative engineering design."

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