'The 80/20 Criteria for the SUCCESSFUL Implementation of CFD/CAE within the Design Process…'

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The Pareto Principle or 80/20 rule states that for many events eighty per cent of the effects come from twenty percent of the causes. For example, in economics the richest twenty percent of the population earns eighty percent of the overall income. In the product development world eighty per cent of the product performance or project success is often dictated within the first twenty per cent of the development life-cycle. However, to what extent can this also applied to the Computer Aided Engineering (CAE) world? Is eighty per cent of the business value delivered associated with only twenty per cent of the resources deployed, or time spent using simulation technology?

If this is the case, it is time for engineering companies to consider what are the obstacles preventing successful implementation of CAE tools within their design process? From our experience, when a product development group is looking to realize the benefits of computational simulation, there are seven areas of the implementation that need detailed assessment. We refer to these as the '80/20 Criteria for SUCCESS': -

1. *Suitability of CAD models*. Current marketing surrounding the integration of CAE within CAD/PLM systems tends to encourage companies to assume they can take any production CAD model and instantly run a computational simulation (CFD or FEA). However, even when this is possible, it is not necessarily a very efficient way of running a CFD/FEA model. The computational mesh automatically produced can be over dense in areas that are of little significance to the physics with the consequence that the solutions take too long to run without any gain in accuracy. One solution to this is to de-feature the CAD model, however, this can often require many hours of work and may require the simulation engineer to learn the full complexities of the company CAD system. In some cases it may be simpler to start again from scratch with a concept version of the geometry, in the company CAD system or elsewhere.

2. *Development Process Change*. In some companies the design resources available to use the simulation technology may prefer 'more traditional build and test' development methods, and therefore may lack a real desire to make optimum use of the computational simulation facility. The concept of simulation driven design is that CFD/FEA models are run frequently during the early stages of the design process so that any potential issues are resolved before the design is too costly to change. This is more effective if users believe in these process benefits and the specific technology available to them and feel simulation is part of their process rather than just some final verification step. On the other side to this management themselves may not allocate enough 'upfront' time or resources within specific project plans so more 'Traditional' processes and project metric systems are maintained.

3. *Operating Environments and Material Properties.* Knowing how to represent reality within a computer simulation should not be underestimated. Unless the definition of the boundary conditions match the real life situation then there is a risk that results obtained won't be useful. Equally material properties need to be known or, if not, then adequate assumptions made so as not to affect the validity of the predicted results. Electronics enclosures for example are very sensitive to material property conduction paths. Flows through valves can be very sensitive to the pressure conditions applied, for example an incorrect operating condition can cause choke or cavitation to be predicted making the results not valid.

4. *Experimental Test and Verification.* Confidence in simulation results is often required before CFD/FEA is really accepted as part of the design process. Verification of a CFD tool is often performed by comparison of test data with the simulation results. However, if they don't match the CFD tool is often blamed and the whole concept of using simulation thrown out. In these situations it's important to make sure that the test data is challenged in terms of calibration, sampling method, apparatus used and validity of comparison between what has been tested and the simulation model before drawing any conclusions.

5. *Appropriate Computer Resources*. The computer resources required for a given application may be prohibitively expensive to purchase and maintain with respect to the Return on Investment (ROI) that will be realised. For example, if every design iteration of a pump model, requires a full transient CFD simulation at enough points to define the operating curve, something more than a standard CAD workstation computer may be needed, unless the right choice of CFD tool has been made. Or if a given model requires a very large computational mesh (e.g. 5 million+ cells) to provide meaningful results, such as a Wind Turbine, then again a standard workstation may not be up to the task if users have access to an unsuitable CFD tool for that application.

6. *The Phenomena of Fluid Dynamics*. Some application's physics may have some unusual Fluid Dynamics phenomena occurring. Design focused CFD tools are developed to make life easy for the majority of users who are running the most common types of applications (The 80/20 rule applies here as well – twenty per cent of the what is possible with CFD tends to cover eighty per cent of the potential flow and thermal design applications). However, this can mean that when there is something unusual about the physics of the application, even though it may look like it is within a design focused CFD tool capability, the user may find it difficult to get relevant results from the models or is required to delve deep into the background of the software to find a technique that does produce reasonable results. An example of this is an external aerodynamic model where the user needs to closely control the mesh around the working surfaces and may also need to change many of the default settings on the turbulence model.

7. *CFD and Complex Physics*. Some Fluid Flow applications can be so complex that only high end CFD tools, developed for the full-time analyst or educational establishments, are appropriate. These applications, such as flows with chemical reactions/combustion, multi-phase fluids or free surface flows, are normally way beyond the capabilities of design focused CFD tools. This may be because they do not fit within the 80/20 principle mentioned within Criteria 6 above and therefore the software vendor has decided that they are not economical to develop. Other complex physics capabilities may be left out because they require the knowledge of an engineer who has a PhD in numerical methods just to understand the required input (and/or output). This can mean that some companies are left to justify recruiting the services of a CFD expert, with the cost of the appropriate high end tool, to address that particular application.

CONCLUSIONS

With all these potential obstacles in the path of a successful implementation of a design focused CFD/CAE strategy, is it still worth the investment of time and money? Our opinion is "**YES, ABSOLUTELY**" because once the technology is **SUCCESSFULLY** implemented significant prototype cost savings and quality improvements become a standard part of the design process. The important point is to recognise what potential implementation barriers exist early-on and make sure there are plans in place to overcome the issues as they occur.

Of the seven criteria mentioned above the first four are best addressed through planned training and adequate education. Both formal training courses and one to one mentoring with experienced engineers are recommended. By 'experienced engineers' we mean those who have seen many other companies go through a **SUCCESSFUL** design based implementation process many times before. Only these engineers will have the knowledge to understand what is happening when simulation results do not exactly match experimental data.

If computer resources are identified as a potential issue then partnering with an organization which can provide access to fast high performance computing clusters could be an answer, to overcome the bottleneck. However, an **assessment of the CFD technology** in use would also be a recommendation.

Unusual Fluid Dynamics or Complex Physics are best addressed by also partnering with an organization that is able to offer design focused solutions whilst providing access to advanced high-end consultancy services. Many companies find this very economical, particularly if their unusual or more difficult applications are only a small part of the potential benefit CFD will bring to their design, research and development efforts.

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