STEPS FOR PERFORMING COMPUTER-AIDED ENGINEERING (CAE) SIMULATIONS

Designing through computer-aided simulations (Computer Aided Engineering, CAE) goes far beyond knowing how to use software and extract results. The output depends entirely on the input provided, so a rigorous process must be followed to ensure results are reliable and relevant. Moreover, detailed simulations can require significant computational resources and time, making it essential to avoid unnecessary steps and use all available knowledge efficiently.

1. Translate the initial design specifications into concrete values

Initial specifications are often too generic. They must be converted into quantitative values that can be used as simulation inputs. When necessary, reasonable assumptions must be made for variables that are insufficiently defined.

2. Define the type of modelling to use

Engineering problems can be studied with different models: analytical, statistical, differential equations, finite elements, etc. The simplest model that is still useful for the design should be chosen. Key questions include: What is the objective? What accuracy is required? What resources are available? How much time is available?

3. Pre-design

A conceptual or schematic first design should be created using subject knowledge. This helps estimate initial dimensions and anticipate orders of magnitude for expected results.

4. First design

Using the estimated dimensions, a first digital design is created with CAD tools (Computer Aided Design).

5. Preparing the simulation

The appropriate CAE software is selected and the CAD geometry is imported, often through STEP or IGES files. The geometry is meshed with adequate quality, and boundary conditions, initial conditions, and physical models are defined.

6. Solving the problem

Even though the CAE software performs the numerical solution, understanding the underlying models and numerical methods is essential to ensure correct results and troubleshoot issues.

7. Checking convergence of the solution

Residuals must decrease and solution values must stabilize. If not, the solution cannot be considered reliable.

8. Critical analysis of results

Results must be carefully interpreted and compared with prior expectations. If unexpected behaviours appear, input errors or configuration issues must be checked.

9. Mesh convergence

It is essential to verify that the mesh has sufficient resolution. A finer mesh is used as a reference to compare errors, selecting the coarsest mesh that still meets acceptable error thresholds.

10. Evaluate the design

Once the validity of the results is confirmed, the design must be checked against the initial requirements.

11. Improve the design

Design is an iterative process. If requirements are not met, improvements must be proposed rationally, avoiding reliance on trial-and-error alone, which is often inefficient and uninformative.

12. Experimental validation

Experimental validation is the most reliable method for confirming simulation results. When experiments are not possible, documented reference values may be used, although in industrial contexts physical testing is expected.

13. Report and conclusions

A final report must be written explaining the design process, justifying decisions, and presenting the conclusions derived from the CAE simulations.

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