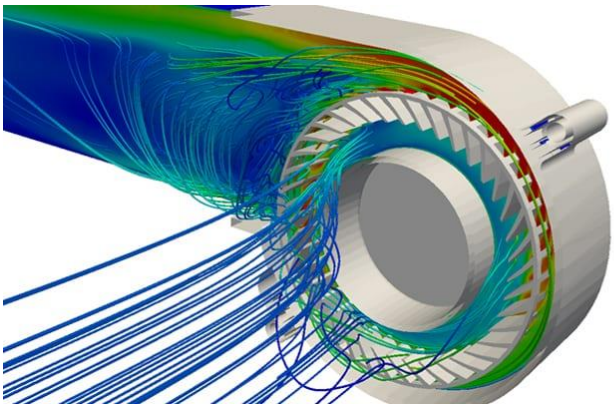
What affects the cost of CFD simulations and analysis?

One of the most intriguing questions from our clients is how much it costs to run a CFD simulation. The answer to this question, as in many other cases, is "it depends." In this article, we will try to answer it, introduce the elements that significantly affect the cost of a simulation, and tell you what are the ways to reduce such cost.

What makes up the final price of a CFD simulation?



There are many factors, but it is worth remembering that the value of a project is usually proportional to the amount of time an engineer must spend on the various steps required to perform a CFD simulation. The final price of the simulation is also affected by the license fee for the software that is used to perform the simulation (e.g. Ansys Fluent, Solid Works, Star CCM, etc.). Depending on the complexity of the project and the objective to be achieved, prices can fluctuate from the original indication by as much as 50% in either direction, which only makes it more difficult to indicate exact amounts for a given project.

Let's go through the basic steps that need to be taken to perform the simulation.

The first is to prepare the geometry. To perform a simulation, it is necessary to have a geometry that will be the computational domain. There are two possibilities for this stag

- Customer-supplied geometry

In this case, once the finished geometry is received, the engineer's work focuses on adapting it to the requirements of the CFD analysis. What does this mean in practice? Removing elements that will not have a significant impact on the flow (e.g., structural elements, locations for measuring apparatus). This is to adjust the geometry for the next step, which is to apply computational meshes to the resulting geometry. Leaving in the computational domain, any element that does not significantly affect the flow causes the computational mesh to have to be compacted around such an element, and this, in turn, increases simulation time. The domain should be simplified to the point where the representation of real flow is preserved and the removed elements do not affect the quantities analyzed in the simulation.

- Creation of new geometry

If the customer is unable to upload geometry or does not have such a model, we can create such geometry ourselves, using commercial software such as Solid Works

Interestingly, in some cases, creating geometry from scratch can take less time than simplifying the complex assemblies we get. Choosing to do so allows you to quickly create geometry that doesn't

contain unnecessary details and makes it easier for further modifications in the future. It is worth considering this option before working on one of the above options.

The next step is to superimpose computational grids.

This step requires the imposition of a computational grid on the created domain, which allows the entire geometry to be divided into smaller computational cells in which flow calculations will be carried out. The principle of creating computational grids is a difficult topic that deserves a separate article. In a nutshell, it is necessary to divide our geometry into a sufficiently large number of elements to reflect important flow phenomena such as a boundary layer, local flow disturbances, or high velocity or pressure gradients.

1. Set the simulation parameters

At this stage, we give the simulation boundary conditions and select mathematical models. Next, we decide whether the simulation will be run in steady-state or non-stationary conditions. Stationary simulations allow us to learn about steady-state operating conditions, but for some issues, it is necessary to perform non-stationary simulations. The duration of such simulations is several times longer than that of stationary simulations. This difference is due to the need to perform the same calculations for successive time steps.

Depending on the purpose of the simulation, the equations of turbulence or heat transfer models are taken into account.

2. Processing of results

After completing the simulation, you should choose the appropriate form for presenting the results and summarizing them. The obtained results should be described in the form of a report and subjected to critical analysis. Its purpose is to check whether the obtained results are close to real values and possible to achieve in reality.

The final part of the report is the analysis of critical points and the determination of further steps for development.

How to reduce the cost of CFD simulation?

The ways are several. Customers need to get the most accurate results at a price that is attractive to them. However, it happens that the need to perform a series of simulations for different variants causes the total cost to start rising significantly. How you can reduce this value, but still get equal quality results is presented below.

1. Recurring variants.

This scenario occurs most often when simulating the ventilation system in buildings. In this case, often several rooms are designated for analysis. Some of them are identical, which allows you to perform analyses on only a part of them since for subsequent variants the results will be identical.

2. Outsourcing multiple cases in one order

This way allows for parallelizing the work of the engineer working on the project. If we plan to perform, for example, 7 simulations, then splitting the project into 3+4 variants adds up to more time than performing all the variants at once. Analysis of a larger number of cases allows parallel execution of the tasks described above, e.g. while waiting for the results of one simulation, post-processing of the results in the previous one is performed or the final report is completed.

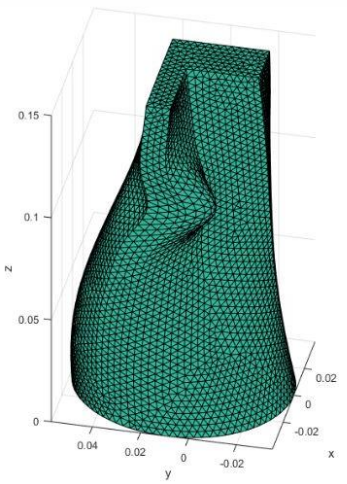
3. Analytical calculations.

If simulations are used to determine, for example, the optimal operating parameters of the cooling system, it is worth performing analytical calculations before starting CFD analyses. They will allow us to narrow down the range of values for which we will make changes. Our engineers can determine the approximate parameters and then, based on the calculations made, transfer them to the simulation program.

Interestingly, in some cases, you can limit yourself to analytical calculations only.

4. Create a dedicated application:

In cases where none of the above methods give satisfactory results, it is worth considering the creation of a dedicated application. This solution is especially recommended if you perform dozens of analyses per year, which will concern a specific area/product. At QuickerSim, we have experience in performing such applications for automotive, ventilation, plastics, and many other industries.



What characterizes simulations performed with a dedicated application?

- Ease of use - the user of such an application does not need to have specialized knowledge of fluid mechanics, since most of the key issues are implemented by QuickerSim so that the model selects the key elements automatically
- Speed - simulation results are obtained in much less time than with conventional software while maintaining the accuracy of the calculations.
- Cost of operation - the resulting application is owned by the customer and does not require paying an annual license or incurring additional maintenance costs. The total cost of the application is comparable to the prices of several commercial software licenses.
- Ability to develop models - the created application can be developed and improved. Undertaking development work will expand the range of calculations that can be performed with it or reduce the time required to obtain results.

Sample simulation quote:

The analysis is to check the airflow for the designed HVAC system, from the analysis we want to get the temperature distribution inside the rooms, and the velocity analysis in the occupied areas.

The geometry is not provided to us by the client, we only have the building plan, and we create the geometry ourselves.

There are 4 rooms to analyze and 3 outdoor temperature values for each room.

This gives a total of 12 simulations to be performed.

Two of the selected rooms have the same dimensions and distribution of ventilation openings. This allows you to reduce the number of individual analyses to 9, because, as described earlier, the results for two rooms will be identical.

The procedure for preparing the analysis is as follows:

1) we create the geometry of 3 rooms including the ventilation system
2) We superimpose the calculation grid on the created geometry
3) we select the appropriate calculation models, set the boundary and other conditions
4) We perform the simulation
5) We then process the obtained results and subject them to critical analysis.
6) we create a report containing the simulation results and suggestions for potential improvements.

In this type of assignment, we usually provide a breakdown of the cost of the various options. The main cost of the above analysis will be the execution of the first simulation. The model created is often revised and verified to assess the quality of the results obtained. This results in the need to perform additional verification analyses.

Each subsequent simulation is already a different case, the cost of which is much lower than the first, base case.

Simulation of a new room for which we need to create new geometry and perform again the tasks described in points 1-5. This is a cost of about half the cost of the first simulation.

Checking the already created geometries with superimposed meshes and checked computational model involves only going through points 3-5 and a cost of about 10% of the value of the first simulation.

So what is the cost of analyzing the case described above?

This type of full analysis has a cost of PLN 18,000 - PLN 23,000.

As mentioned above, this is only an approximate valuation for a particular case and a particular type of premises, and the final amount may vary by up to 50% depending on the complexity of the project. We prepare an individual quote for each project. As a team, we try to propose a solution that will best fit the client's budget and bring as much value as possible.

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