SIEMENS
Ingenuity for life

Academic

Gdańsk University of Technology

Gdańsk University of Technology uses Siemens Simcenter solutions in education and research

Product

Simcenter

Business challenges

Prepare students for careers in ocean engineering, marine engineering and naval architecture

Conduct advanced scientific research projects

Keys to success

Implement Simcenter STAR-CCM+ software for CFD

Apply CFD technology in degree programs and research projects

Cost-effective licensing and support

Results

Served CFD needs of a wide range of engineering specialties

Supported students in projects including international human-powered submarine design competitions

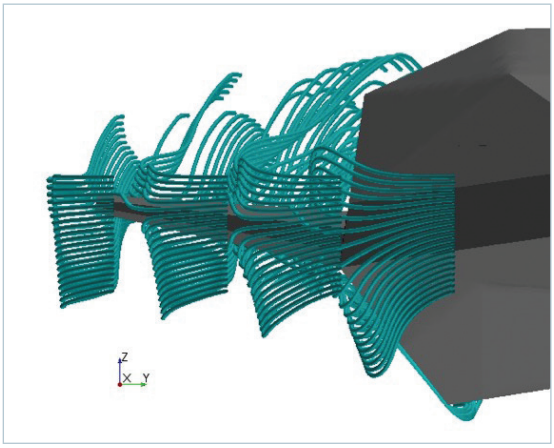
Simcenter STAR-CCM+ has become the major CFD tool for simulation of fluid flow at the university

A leader in ocean engineering and ship technology

Established in 1904, Gdańsk University of Technology (GTU) is one of the oldest autonomous national universities and the oldest technical university in Poland. Today it reinforces its position among the best technical universities, certified by national rankings and international authorities.

The Faculty of Ocean Engineering and Ship Technology at the university offers a Ph.D. degree program that tailors the course of study according to the interests of both the student and industrial partners, preparing student for teaching, research and commercial careers in ocean engineering, marine engineering and naval architecture.

The university makes extensive use of computational fluid dynamics (CFD) simulation in its education and research activities, and the tool of choice is Simcenter™ STAR-CCM+™ software from Siemens Digital Industries Software. The cooperation of Gdańsk University of Technology with Siemens began during the "No engineer left behind" program launched by CD-adapco at the onset of the economic crisis in 2008. The support scheme initiated by CD-adapco enabled engineers who had lost their jobs, or were at risk of losing them, to retrain in CFD simulation and change professions by providing free-of-charge access to software licenses and training. After CD-adapco was acquired by Siemens and included in the Simcenter software family, the name of the package was changed to Simcenter STAR-CCM+; since then, it has been playing a major role in Gdańsk University of Technology teaching programs.



Visualization techniques are used to present the calculations results as current lines.

"Not so long ago, the only method of testing the water flow around ship hulls was testing in a model pool at scales from 1:20 to 1:50...At present, we replace these cost- and time-intensive tests with CFD simulations."

Dr. Cezary Żrodowski
Department of Ship Design and Subsea Robotics
Faculty of Ocean Engineering and Ship Technology
Gdańsk University of Technology

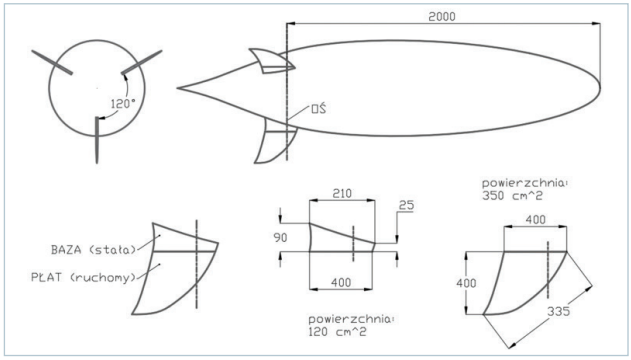
"Simcenter STAR-CCM+ is perfect for teaching and for work with students, as well as for advanced education in the field of CAD/CAM/CAE," says Dr. Cezary Żrodowski of the Department of Ship Design and Subsea Robotics at the university. "At present, it is one of the primary CFD tools of our Ph.D. students. Both the licensing method and the culture of its use make this software the preferred solution at our university. Among other things, students may use the licenses on a 'power on demand' basis not only at the university, but also on their private PCs at home."

The CFD process

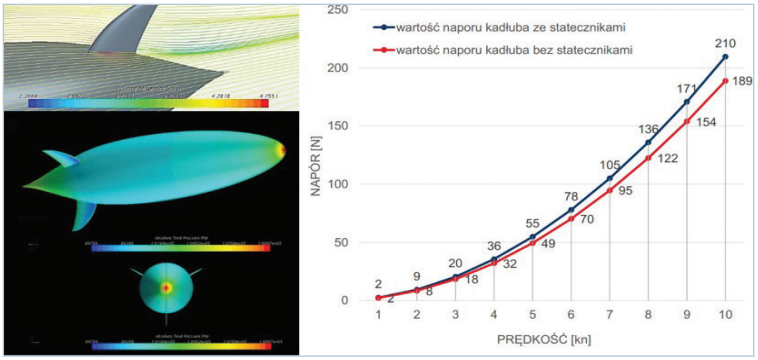
The CFD simulation process is typically long, and the time required depends on the accuracy of calculations adopted by the engineer. "Depending on the particular research center, simulation procedures may differ significantly," Dr. Żrodowski says. "Usually, the process consists of three to four stages. First, the so-called geometry is prepared, then the computational domain is defined, added to the model in the form of a grid, embracing water and air around the examined body."

Finite element and finite volume simulation methods are based on discretization of space: the test area is divided into a mesh. It is an arduous process that requires experience and has a significant impact on the value of results. Increasing the density of the simulation mesh enables more accurate results that closely reflect real-world behavior, but simultaneously makes the simulation time longer. It is easy to generate a model so large that waiting for the results would take decades. Engineering assumptions are always a compromise between accuracy and the calculation time. The simulations enable solving of various types of flow-related problems – from those in micro scale associated with chemical reactions, to those in macro scale, such as water flows around a ship hull or in a river bed.

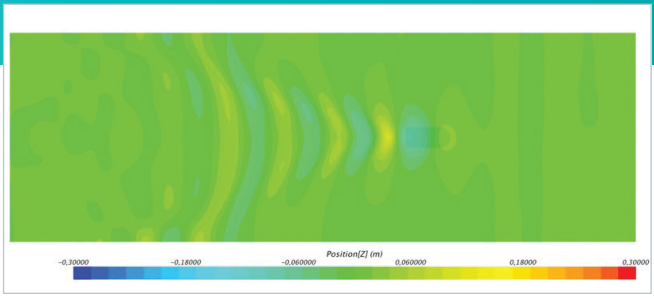
Simcenter STAR-CCM+ enables users of the software to develop custom macros to automate the activities required during a normal ship design procedure and during model tests. "Not so long ago, the primary method of testing the water flow around ship hulls was testing in a model pool, usually at scales from 1:20 to 1:50," Dr. Żrodowski says. "Next, the results of such tests were applied to the behavior of actual ships. At present, we complement and most often replace these cost- and time-intensive tests with CFD simulations."



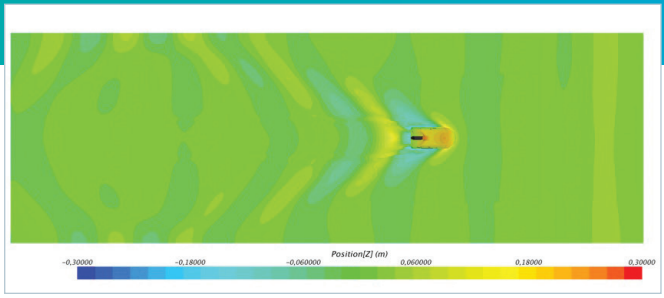
The drawing of the rudder blade of Nautilus.



Simulation of vessel pressure parameters.



The shape of free surface generated by a partially immersed moving object.



The shape of free surface generated by a fully immersed moving object.

Simcenter STAR-CCM+ also offers specific simulation tools and procedures to meet the needs of the marine industry. The Estimating Hull Performance (EHP) module provides naval architects with a streamlined process to simulate powered hull performance, reducing reliance on scaled-model testing in pools. Engineers can simply prepare the appropriate shape of the analyzed model and enter the data to the software. Results from the simulation are consistent with those of pool testing.

Model calibration

Even with the advancements in simulation technology, pool tests are still needed and even necessary in order to properly prepare the computational model. To obtain results that correspond to real-world behavior, it is necessary to properly calibrate the model by adjusting its equation coefficients. With these adjustments, such models can be used to simulate hundreds of modified body shape variants, with high reliability of the results obtained. The percentage of physical tests performed is gradually getting lower in favor of CFD simulations. The use of experiments in the pool are expected to be limited in the near future exclusively to those necessary to calibrate the computational model.

"The object of simulation is rather the medium in which it moves, instead of the ship itself, and in case of sailing vessels, it is also the wind. A ship, the coast or a bridge are in fact obstacles for the fluid, and during the simulation we deal with what happens to a fluid or gas after it encounters either static, moving or deformable obstacles," Dr. Żrodowski says. "Our job is to find out what happens to the fluid after such an encounter. Sometimes flows are laminar, but in ship technology most often turbulent. Usually, the result of a simulation performed by an engineer is the distribution of pressure generated by a given flow. Entering the correct fluid characteristics to the model allows us to determine the hull behavior under the influence of waves, and to detect any irregularities, such as the possibility of water getting on board the ship, or the risk of capsizing."

Usually, the object target parameters are assumed so that the model simulation results are clearly on the safe side in relation to the requirements. This results from the limitations associated with the model accuracy and the quality of available data, which requires the adoption of significant safety margins.

"Simcenter STAR-CCM+ is perfect for teaching and for work with students, as well as for advanced education in the field of CAD/CAM/CAE. At present, it is the basic CFD tool of our Ph.D. students. Both the licensing method and the culture of its use make this software the preferred solution at our university."

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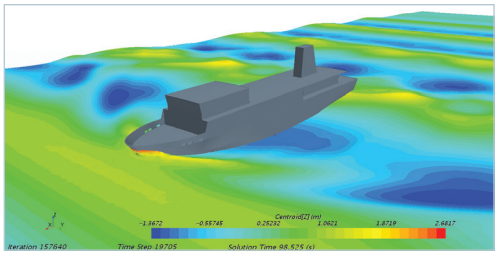
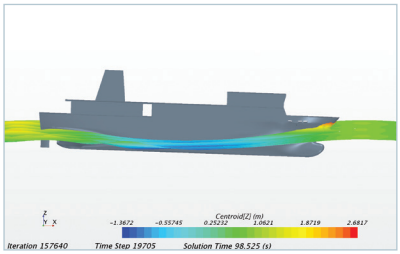
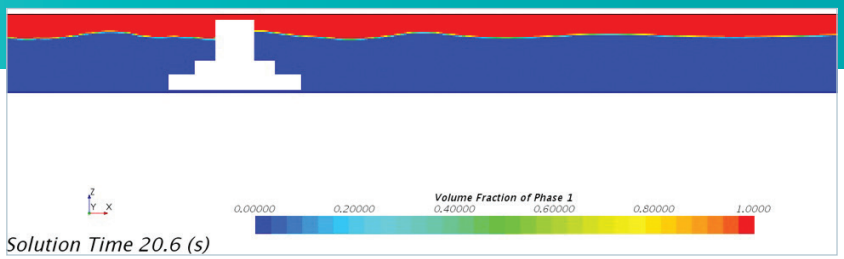




Simulation of hull behavior on the wave. Source: Niklas K., Pruszko H., Żrodowski C., Selected results from 'SmartPS - Smart Propulsion System'; project no ERA-NET MARTECII/ SmartPS/4/2016; Gdansk Univ of Techn, Gdansk 2018



The simulations of the influence of waves on a stationary object. The software accurately calculates the forces generated by sea waves.

Simcenter STAR-CCM+ is used by students to complete numerous projects. Last year, students completed a project for a human-propelled submarine, Nautilus, which was widely reported by the media and participated in the International Submarine Races (eISR) competition.

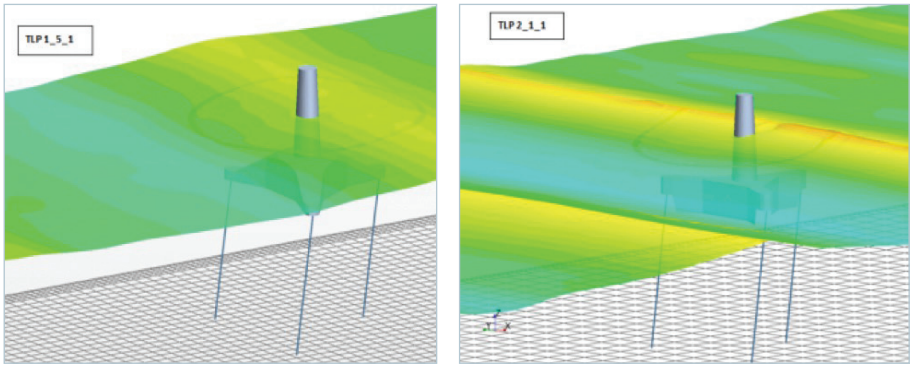
Simcenter STAR-CCM+ supports work of various engineering specialties

Pressure calculations made using CFD tools are carried out independently from strength calculations. However, more and more often thanks to the tools like Simcenter STAR-CCM+ the university can include the interaction of structure and fluid (FSI – fluid structure interaction). This allows study of the behavior and strength of the structure based on hydrodynamic loads that approximate real ones, instead of the traditionally oversized regulatory loads.

The tests performed using Simcenter STAR-CCM+ may relate both to the behavior of fluid on the ship hull surface and in the area of the screw propeller. The engineers designing the ship shell plating perform the hull simulations, while the propulsion experts are interested in what happens in the propeller area in terms of vortexes and vibration.

On the other hand, engineers dealing with the ship steering perform simulations for the rudder area. The most important things for sailboat designers are the flow of wind around the sails, and the noise generated during such flow. Simcenter STAR-CCM+ also enables engineers to predict the spread of fire on a ship, and the software can be used to simulate behavior with respect to fire safety.

"When designing the ship, we want to know where such negative phenomena – the detachment of the flow from the hull, and in the case of propellers, cavitation – occur," Dr. Żrodowski says. "Traditionally we focus on estimating resistance, which has a direct impact on fuel consumption, but modern software also allows you to simulate maneuverability, seakeeping or stability. When testing a model, we try to find answers to the following questions: Should we add extra keels to minimize the ship rolling and pitching, or should we add some elements modifying the flow near the propeller to increase the propulsion efficiency, or to minimize vibration generated by this type of part in order to improve the comfort of work? Simcenter STAR-CCM+ is a universal tool for many specialties. CFD allows us even to create steel rolling models, as in certain conditions steel can be treated as a fluid."



The waves-induced movement of anchored objects.

Simcenter STAR-CCM+ for students

The software is also used for professional scientific projects, including the design of ships or offshore drilling rigs. Approximately 50 students use tools integrated with CFD to perform the simulations of individual geometries. Some of them perform more advanced fluid mechanics simulations. The tools are also used by Ph.D. students working on commercial research projects concerning offshore platforms and sea wind farms.

Solution/Service

Simcenter STAR-CCM+
siemens.com/simcenter

Customer's primary business

Established in 1904, Gdańsk University of Technology is one of the oldest autonomous national universities and the oldest technical university in Poland. Today it reinforces its position among the best technical universities, certified by national rankings and international authorities.
pg.edu.pl

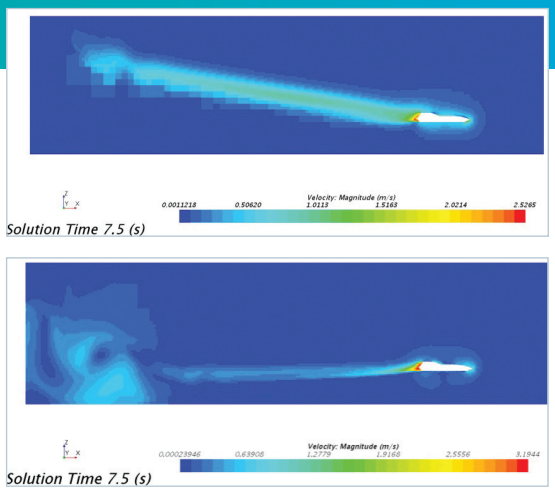
Customer location

Gdańsk
Poland

"Simcenter STAR-CCM+ is oriented for use by engineers," says Dr. Żrodowski. "It does not require highly specialized knowledge to start calculations, but simultaneously, it includes many advanced features that support complex research projects. The integration with the system during modeling of the geometry is important. The software accurately simulates fluid mechanics. The ability to purchase the so-called core hours is very convenient and results in significant reduction of research costs. At the same time, the data generated by the educational and the commercial versions are fully compatible with each other. The compatibility allows users to continue the work started as student exercises during later research at master or doctoral studies."

The Nautilus project

Nautilus is the name of the submarine built by the students of the Piksel Research Club of Gdańsk University of Technology in preparation for a competition in the United Kingdom. It is 2.7 m long and its section reaches merely 61 cm. The designers wanted their submarine to be as small as possible and to generate the minimum water resistance.



Calculations of the forces acting on an object moving along a given trajectory.

The submarine participated in the International Submarine Races (eISR, European ISR) competition of university student teams that takes place each summer in Gosport. The job of the teams is to design and build a human-propelled racing submarine and then to win the race. The entire simulation and calculations for that project were carried out using Simcenter STAR-CCM+. Students also design pedal and solar-powered boats.

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