The Faculty of Mechanical Engineering, Univesity of Belgrade

Report on my stay at the Institute of Turbomachinery, the University of Hannover

student: Maja Macic

My name is Maja Macic and I am a student of the Faculty of Mechanical Engineering, University of Belgrade, Department for *Turbomachinery*. At the age of fourteen I knew that I wanted to become a mechanical engineer. A few months ago only three exams were the obstacle to fulfill my wish and at that time my professor Milan Petrovic gave me an opportunity to get the scholarship from DAAD and to come to the University of Hanover (Institut für Strömungsmaschinen) and spend here two months. I got the scholarship from June 1st until August 1st.

However two months were not enough to finish my work in Hanover, and I have got the new scholarship from the University of Hanover. I will stay here until the October 25th. I am very happy that I have the chance to finish my work here and to have a complete support of my colleagues, which is very useful. This stay helped me to become sure that my choice about my future job was more than correct.

On the first day here I got to know new colleagues and more about the Institute‘s experimental facilities and equipment. The Institute of Turbomachinery at the University of Hanover was founded in its present capacity in 1970 and has since developed into one of the largest German institutions in turbomachinery research, covering axial and radial compressors, turbochargers, steam and gas turbines. Nineteen graduate research assistants and ten technical staff (technicians and machine shop personnel) are engaged in the current research topics and use the experimental equipment. Particular emphasis is placed on the adaptation of state-of-the-art instrumentation techniques for unsteady flow measurements to turbomachinery.

My first impression was that I was quite astonished with the opportunities which employees have here, which, unfortunately, we don’t have at our University of Belgrade. We don’t have option to run the real machines and to do some bigger experiments. A very well equipped laboratory is a great opportunity to combine the reality with theoretical knowledge .

The purpose of my stay has been to learn to work Star-CD. Star-CD presents a general purpose industrial thermofluids analysis code, suitable for application to flow, heat and mass transfer and chemical reaction problems. Among the other industrial thermofluids analysis codes Star-CD presents a future of the engineering.

During first few weeks I did some already solved problems and I was getting into a CFD. Solving those problems helped me to learn and understand some basic things about Star-CD . After some time I was able to do something on my own, hence I got my own project.

The subject of my work is ‘Instationary calculation of the wake region in the low-pressure compressor and a probe‘s influence on the accuracy of measurement of a pressure with Star-CD`. It consists of three parts: 2D steady calculation, which solution I use as a initial solution for the next part – 2D unsteady calculation and the last part is 3D unsteady calculation. 2D mesh presents the mesh which has one cell in z-direction.

At the very beginning it was important to learn the way of thinking which people who work with CFD have. Star-CD requires a precise definition of the physical system’s geometry, material properties and flow conditions based on the best available understanding of the relevant physics.

The first task was to create a proper mesh which presents my flow domain that includes defining: number of cells, size and distribution of cell dimensions, etc. My mesh consists of

two blocks of cells, where the first part contains the cells which presents a small part of the wake region and a remaining part of the wake region is my second block with a probe in it. The first part of my mesh I have had to make moving in order to simulate rotor's rotation. After that I had to specify appropriate physical parameters (e.g. density, specific heat, viscosity, etc.) and choose a suitable turbulence model, which in my case was K-Chen. Since then, I have only heard which turbulence models exist , but now, since I have had to read more about turbulence models and turbulence as well, this part of fluid dynamics becomes very interesting for me and from now on I want to explore more in this field of science.

The next part of my work was to specify the location and definition of boundaries and to write the user subroutine for the inlet, since I have non-uniform velocity and temperature field. In my case I have the inlet, outlet, symmetry planes and 'attach' boundaries, since I use arbitrary sliding mesh with one sliding interface. It is important that boundaries are chosen and implemented correctly, since the outcome of the simulation depends on them.

The person who works with this kind of software has to be aware that he has to balance the requirement of physical fidelity and numerical accuracy against the simulation cost and computational capabilities of his system. Therefore, I needed help from the people who have more experience with CFD modelling. My mentor, Dipl.-Ing. Axel Fischer, helped me to learn how to think and work with Star-CD and I have also had a complete support from the people, who present the Support of Star-CD.

This work also requires moving mesh, as I mentioned before, since I have to simulate rotor's moving and this is a part which I had to do without any help, because research assistants who work here don't have experience with it. I am very glad to say that I solved this part of the problem, too . During work with moving mesh I had to use Fortran 77. Hence, that was a good opportunity to improve my knowledge of programming and to learn something more.

I have learnt to use macros which are important, because there is no "undo"-button in Star-CD and they are easy to create. Using macros user can put the comments, which are allowed by the command "!". Macros make checking for errors easier and help finding causes of problems and one thing which has also been important is that time consuming tasks can be automated.

Post processing is an essential part of any CFD work and it consists of: database operations for collecting groups of cells and vertices, action operations for plotting cell, vertex or wall data and plot characteristics functions that determine the plot type, viewing angle, plot options, etc. I have created for each iteration (e.g. time step) pictures using suitable plot types, colours and range of colours. Those pictures present pressure, velocity and temperature field at every time step. The last part of my work is to create an animation made of those pictures and to make some comparisons with the experimental values.

While doing this work I could say that I learnt a lot about creating the meshes using vertices, shells, splines, patches and blocks and different meshing techniques such as: extrusion, using cell layers and using multiple blocks, how to check the mesh quality, to create finer mesh in regions where high gradients are to be expected, to match cells using arbitrary and integral matches. . Creating and checking a suitable and efficient mesh is the most time consuming part of the model setup. It has been also important to understand the physical meaning of each boundary type and to recognize where I could use each and to apply appropriate boundary values, to do well post processing, etc.

The aim of the project was to help to minimise the errors which one does measuring the pressure with a probe. From this point of view I could say that a presence of the probe, which presents a strange object in the flow domain, does significant changes of flow field.

With the time passing I was getting better and better and now I when I am close to the end I can say that I have learnt a lot, but I still have to learn much more.

This is the first time I have been working with this kind of software and it has been a brilliant experience . From this point of view, I can see that I have more opportunities than I could imagine before. Now, I am eager to learn more and more about the Computational Fluid Dynamics and it‘s surrounding.

During my stay here I met new friends and colleagues from all over the world. I am very glad that I have had the chance to meet the people such as Prof. J. Seume and his research assistants who have helped me a lot and have let me feel as if I am a member of their team. They are very friendly and open-minded young people. Every single day I spent here I will never forget. Few weeks ago we had a beautiful excursion. We had a boat trip and a barbecue. That was a great chance to see that they are not just good colleagues, they are great friends, too. I like very much working atmosphere at this Institute and would be very satisfied to work one day with such kind of people. I am sure that we will cooperate in future and exchange our experiences.

This stay has enabled me to get to know something more about German culture and their customs and also to compare the knowledge of Belgrade’s students with Hanover’s.

Thanks to DAAD and opening the new SimLab in Belgrade, from now on the students from Yugoslavia will have a chance to work with Star-CD and to try to follow new engineering and computer development and I am happy that I will continue with my work in Belgrade and improve my knowledge. I would be very glad to help all my colleagues who want to know more about CFD and Star-CD and to share with them my experience here.

All mechanical engineers have to be aware that CFD represents future of engineering and I would be very glad to be a part of it and give my contribution to it’s development.

This stay at the Hanover’s Institute of Turbomachinery and work with these people was much more that I could have expected . I would be very satisfied if I had a chance to be here again .