HydroFlex

Newsletter #4 Contents

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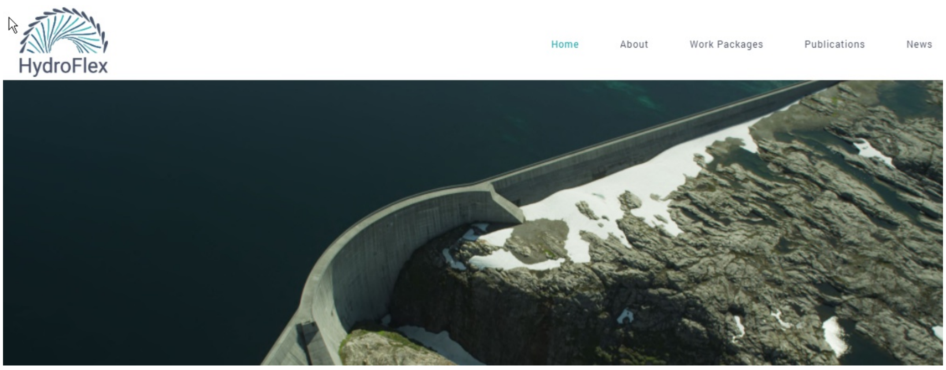
www.h2020hydroflex.eu



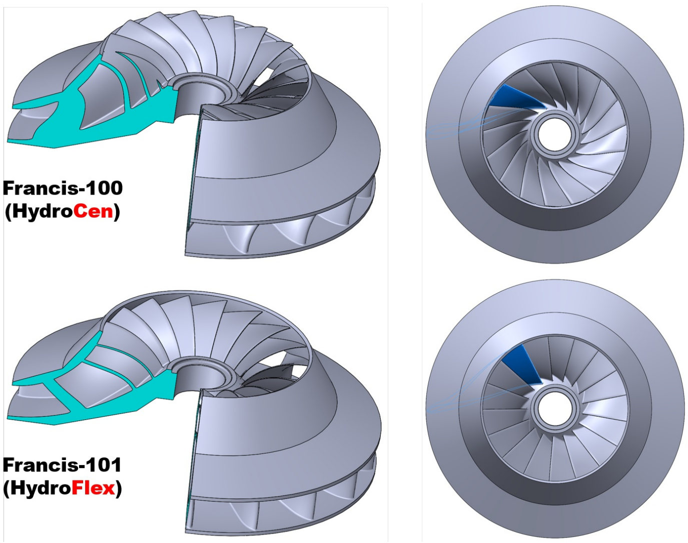
This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 764011.

1. Greetings from the WP leaders - WP 3: Flexibility of turbines

In every newsletter we challenge each of the work package leaders to present their vision for the HydroFlex project. We hereby present the team of WP 3 : Flexibility of turbines

Igor Iliev, Ph.D.
Postdoctoral Researcher
Waterpower Laboratory
Norwegian University of Science and Technology (NTNU)
HydroFlex project:
WP 3 leader

During the year of 2017, I was introduced to the idea and concept of the HydroFlex project for the first time. At that time, I was working under HydroCen and, as a side assignment; I briefly took part in the proposal stage of the Work Package 3. In my opinion, the concept was/is a breath of fresh air since it has addressed one of the most challenging aspects of hydropower – the need for a higher flexibility and availability. Moreover, it was elegantly done by bringing together researchers and experts from all fields concerning hydropower, and with a clear goal to broaden the horizons and understand the bigger picture even better. As of March 2020, I am appointed a WP-3 leader and our main task is to accommodate the prime mover – the turbine, to the future needs of hydropower.Already in May 2020, the HydroFlex project will be halfway through its planned period, and so far, several important milestones and deliverables have been fulfilled. Based on the preliminary results provided by all WPs, it becomes even more obvious that increasing the flexibility and availability is complex and multidisciplinary task. Furthermore, during the current three-months-period, i.e., between project months 22-24, the number of deliverables and milestones is timed to reach its peak. It is a pride and joy for all of us to see HydroFlex gaining its momentum and speeding towards its final goals.
My vision for the HydroFlex project is that it should provide with reliable simplifications that will allow us to deal with the complex nature of flexibility in an affordable but accurate manner. Being a product- and solution-oriented project, it should also provide with engineering tools and practical knowledge that can be directly applied to the future problems in the European grid. Doing so, a valuable group of experts and engineers in their respective fields will be trained - one that will be more aware of the multiple aspects of hydropower then the previous generations were. Finally, before anyone can provide good answers, one needs to pose the right questions first, and that is, perhaps, one of the most difficult tasks for the future research. Historically speaking, similar projects have always had a significant contribution in that respect, and I expect HydroFlex to be nothing less.



Looking forward to an even more successful second half of the project.
Until then, take care of yourselves and stay healthy!

2. PhD Candidates - A status update

A short status update from our PhD candidates. This newsletter presents Filip Stojkovski who works in WP 3 Flexibility of turbines:

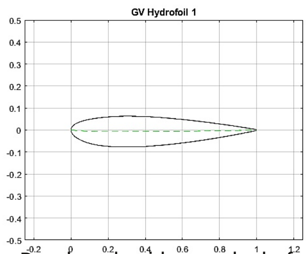
Mathematical and numerical modelling in order to optimize the Radial Guide Vane Cascade for High-Head Variable Speed Francis Turbines

Filip Stojkovski
M.Sc. in Mech. Eng.
Ph.D. candidate at:
“Ss. Cyril and Methodius” University in Skopje
Faculty of Mechanical Engineering Skopje
Institute of Hydraulic Engineering and Automation

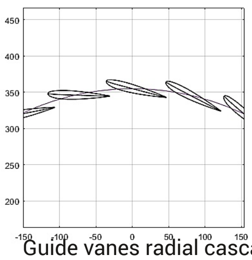
In order to increase operational flexibility of hydraulic turbines, a new approach has been proposed, such as the variable speed operation. As part of the HydroFlex project where I conduct research in Task 3.2. under WP3, my duty is to develop an automated parametric based code which will give an output of guide vane cascade designs, suitable for variable speed operated Francis turbines.The Ph.D. topic is directly influenced from the project task and expanded a bit further. The main goal of the Ph.D. is to focus on the flow field generated between the guide vanes and the turbine runner, i.e. in the vaneless space of the machine, and how to improve it and modify it with the guide vane apparatus to be suitable for variable speed operations and to improve turbine off-design loads, such as Part Loads and High Loads.

Examination of the flow field for different operating points of the turbine is crucial for determining the dominant flow parameters which needs to be examined and further to modify and improve them, to perform efficient “flow feeding” of the runner for the desired operating conditions which are mentioned above. An initial simplified combination of these flow parameters is used and implemented into MATLAB, to obtain a graphical representation of the situation, such as streamlines and their angles which directly influenced the guide vanes initially obtained design. Nevertheless, CFD calculations are necessary and crucial in this case, for obtaining the flow field in 3D.

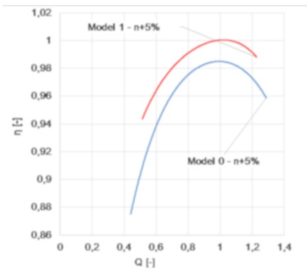
So far, one design of the guide vanes is developed. It has some benefits, but there is still space for improvement. The improvement of the guide vane apparatus is strictly determined from the flow field in the vaneless space and the flow between the guide vane blades, i.e. the inner blade channel created between two blades. Flow deflections and eventual separations must be avoided in the future



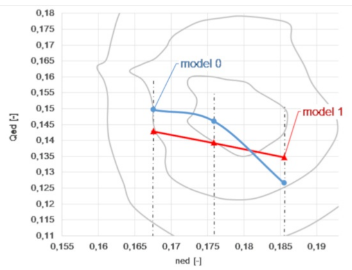
Developed guide vane hydrofoil



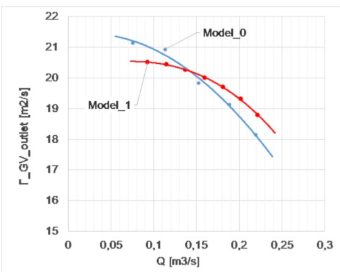
Guide vanes radial cascade



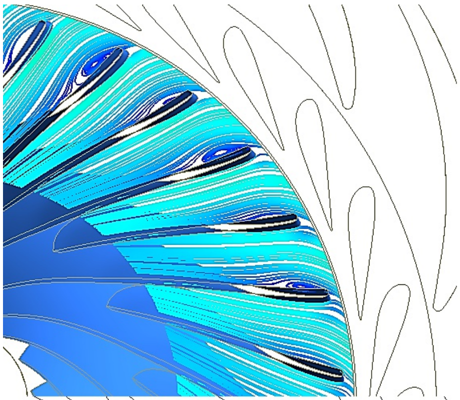
Off design improved efficiency



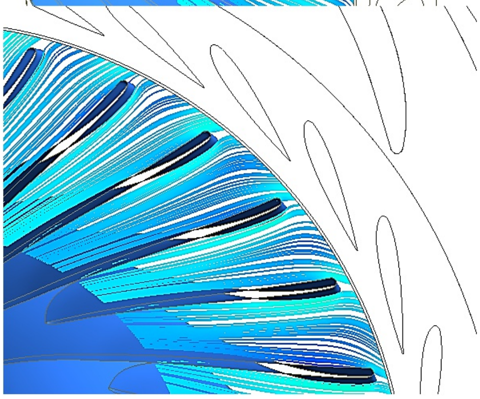
Partial BEP zones connection for overall examination



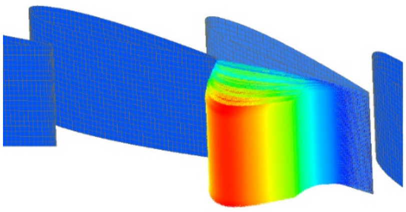
Outlet circulation of the guide vanes as one of the crucial parameters in the flow field



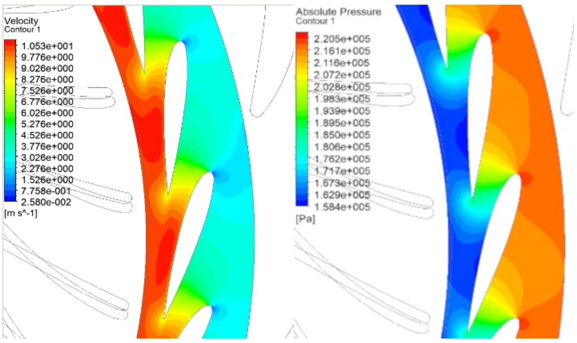
Francis 99 guide vane system operating at off design +5% of rotational turbine speed (flow separations and vorticities in the runner – decreased efficiency)



Initial developed guide vane system operating at off design +5% of rotational turbine speed (no separations and vorticities in the runner – better efficiency)



Examination of the meridian velocity profile for the developed guide vanes



Examination of the overall velocity and pressure field in the developed guide vanes

optimization of the blades design, and added to that, to give an output for the desired flow field in the vaneless space needed for the turbine runner in those partial operating conditions. Several ideas came up for further analysis, which need to be checked, such as straightening the inner blade channel by keeping the outlet angular positions of the blades, or creating a meridian flow based channel shape. Other idea is to perform a water injection through the blades trailing edges to decrease the wakes and crests on the velocity profiles which the guide vanes usually do and by that, to obtain more axisymmetric and undisturbed velocity profiles which will perform overall stabilization of the flow field in the vaneless space.

The results for the initial developed guide vanes are compared with the existing guide vane apparatus of the turbine model Francis 99, where they directly increased the efficiency of the turbine, as the developed guide vanes are primarily thinner, which has decreased energy losses, and improved the operational zone for increased 5% of rotational speed of the turbine. These results are optimistic and can be used for further examinations of the complete process mentioned above.

3. Headlines / Activities

3.1 HydroFlex public webinars

Webinars are a modern and convenient tool for presenting results to project members, the scientific community in large as well as the public. In the current situation, with strong travel restrictions, effective use of electronic communication will be crucial. Hopefully the situation will soon normalize and teams can again meet physically. In the meantime, here is a summary of the current webinars available at the HydroFlex website www.h2020hydroflex.eu

HydroFlex Webinar #1 - 21.03.2019
Defining three European energy scenarios.
The Institute of Power Systems and Power Economics at RWTH Aachen (Work Package 2 lead) has written a report (Siemonsmeier et al., 2018) representing three different future scenarios for the European energy system and the role of hydropower within them. In this Webinar Marius Siemonsmeier presents this report.

HydroFlex Webinar #2 -26.06.2019
Overvoltage phenomena in the field winding of a hydropower generator.
In this webinar Roberto Felicetti (Uppsala University) presents the work done in Work Package 4 regarding overvoltage phenomena in the field winding of a hydropower generator. After introducing the reasons for the increased use of power electronics in the excitation system of synchronous machines, this webinar presents how Work Package 4 is facing the issue of predicting and assessing overvoltage in the unit field winding

HydroFlex Webinar #3 - 26.11.2019
Hydraulic models in Nidelva and Ume Rivers
In this webinar Ana Juárez (NTNU) and Anton Burman (LTU) presents the work done in Work Package 5 regarding social acceptance and mitigation of environmental impact from flexible hydro power plants. The results from simulations of two rivers are presented and the environmental impact and solutions are discussed.

HydroFlex Webinar #4 -05.03.2020
Hydraulic and structural optimization of hydropower turbines for future electricity markets.
In this webinar on Work Package 3 Erik Tengs, Maria Rolstad Jordal and Flora Charrassier from EDRMedeso present their work on a design tool for variable-speed Francis turbine. The presented process, which is fully automated with no need for human interaction, optimizes the turbine design from a hydraulic point of view, as well as considering the structural integrity of the turbine.

3.2 HydroFlex internal webinar

The COVID-19 situation led to the cancelleation of the HydroFlex meeting planed for late April 2020. To permit communication of status and results internal webinars are used. The internal webinars will not be made available on the website.

HydroFlex Internal Webinar - 29.04.2020
Market simulations and grid stability simulations
In this webinar, the colleagues from RWTH will present the main results from WP2. After an introduction by Philipp Baumanns, Marius Siemonsmeier summarize the results of the market simulations. Following this Maik presents the results of the stability studies.

4 A final note: System services

An electric power system is a complex assembly of power sources, transmission-, distribution lines and consumption points. Initially starting as small local and regional systems, over time these have grown to huge interconnected grid spanning many countries. The synchronous grid of Continental Europe (formerly UCTE grid) is the world's largest synchronous electrical grid. With installed capacity of approximately 860 GW, it supplies more than 400 million customers in 24 countries. The modern society is highly dependent on electricity. Maintaining stability of the power system is thus critical. To maintain the quality of supply in the power system it is important to have common, well-defined standards for all equipment connected to the grid. However, faults and unpredicted events will happen. To prevent cascading effects and ensure rapid restoration of services the system operators need tools to respond to events. System services or ancillary services are collective term for services the system operator acquires from the producers and consumers in the grid.
Even though the general terminology is common, there may be regional differences in the nomenclature as well as the technical requirements for different services. Cigre technical brochure 435, 2010, "*Ancillary Services: An Overview of International Practices*" provides the results from two surveys performed in 2006 and 2007. The respondents covered 17 countries in 5 continents. Based on the answers to the survey a classification of seven services is proposed. These are:

AS-1 Primary Frequency Control
AS-2 Secondary Control – Regulation
AS-3 Secondary Control – Reserves spinning
AS-4 Secondary Control – Reserves non-spinning
AS-5 Tertiary Network Control – Replacement of reserves
AS-6 Voltage Control service
AS-7 Blackstart service

Overall the ancillary services from all the respondents can be classified according to the above scheme. Nevertheless the report demonstrates that at the detailed technical level, the meaning of such a "*basic*" service as secondary control varies substantially from one control zone to another. The current work on common Entso-E grid codes may accelerate the convergence of terminology in Europe. Nevertheless it may be advisable to be as specific as possible when discussing system services or flexibility services.

Thank you for your attention!