HYDROVIO

Development of reversible **pumps / hydroturbines** with optimized hydrodynamic and environmental design for high energy efficiency and safe fish passage.

DP PUMPS
DRAKOS · POLEMIS
PUMPS MANUFACTURERS S.A

National Technical University of Athens
Department of Mechanical Engineering
Laboratory of Hydraulic Turbomachines

SINGLE RTDI STATE AID ACTION 'RESEARCH – CREATE - INNOVATE'

European Union
European Regional Development Fund

HELLENIC REPUBLIC
MINISTRY OF DEVELOPMENT AND INVESTMENTS
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COMPETITIVENESS
ENTREPRENEURSHIP
INNOVATION

ΕΣΠΑ 2014-2020
ανάπτυξη - εργασία - αλληλεγγύη
Partnership Agreement 2014 - 2020

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Hydrovio

Water management is being continuously extended beyond irrigation, water and hydroelectric projects to other areas and specific applications, such as pumped storage, aquaculture, waste and sewage management and other technical and industrial projects, that require hydrodynamic machines (pumps and hydraulic turbines) of special design. The company DRAKOS-POLEMIS PUMPS MANUFACRURERS has been activated the last years in the field of special-purpose pumps, with significant presence on international markets and high percentage of exports in its turnover. It employs very qualified technical and scientific staff and continuously researches for new applications.

By implementing the Project, Co-financed by the European Regional Development Fund of the European Union and Greek national funds through the Operational Program Competitiveness, Entrepreneurship and Innovation, under the call RESEARCH – CREATE - INNOVATE (project code:T1EDK-01334) Company faced a new challenge, the design of innovative reversible pumps / hydroturbines with high energy efficiency and improved ecological behavior, allowing for safe passage of fish fauna.

For the implementation of the project the Company collaborated with the Laboratory of Hydraulic Turbomachines (LHT) of the NTUA, one of the largest in Europe, with significant experience and know-how in the analysis of operation and optimal design of hydrodynamic machines, as well as the required potential of high skilled researchers, and advanced engineering infrastructure and equipment

Project had a duration of 3 years and included the following main stages: Initially, the Company selected two design areas for reversible pump/turbines, which are of considerable commercial interest and applicability prospects. In these areas two corresponding reversible machines parametrically designed and optimized by the LHT, using advanced computational fluid dynamics and numerical optimization tools. The design optimization procedure carried out for two concurrent goals: Maximize efficiency and minimize impact on passing fish fauna in both directions.

Company selected one particular machine from each family of optimal solutions (Pareto fronts) and constructed two corresponding complete models. The models installed in specially configured test rigs of the partners in order to measure in detail their operating behavior within a load range, and to validate the reliability and accuracy of the design methodology.

At the same time, important innovative tools developed to support this new product and to enhance the know-how of the two Institutions: Development and application of a cavitation diagnosis system and of a telemetry system for on-line monitoring of machine operation. In addition, development of an innovative computational tool that simulates the fish passage through a hydrodynamic machine and correlates with biological data, aiming at creating a general index of assessment of the fish-friendly performance of a machine, depending on its design and the fish species of a specific site.

Parametrically design and optimization using advanced computational fluid dynamics and numerical optimization tools.

The design optimization procedure carried out with two concurrent goals: Maximize efficiency and minimize impact on passing fish fauna in both directions

- Method Selection for Parameterization with design Flexibility
- Utilizing the Minimum Possible Number of Free Parameters
- Introduction of Parameter Variables to Describe the Geometry of Various Sections
- Automated Modifications of the Initial Design within the Desired Range Each Time

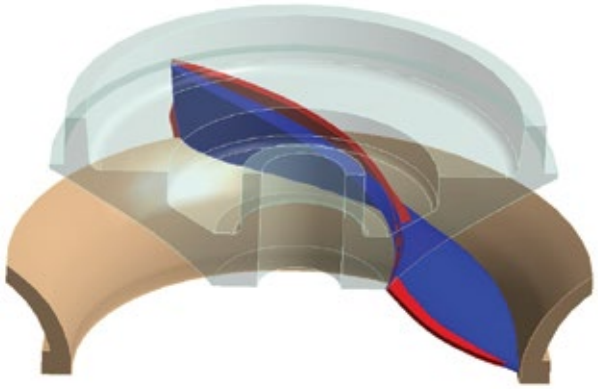
PAT (pump as turbine) machines selection, method of parametrically design & optimization

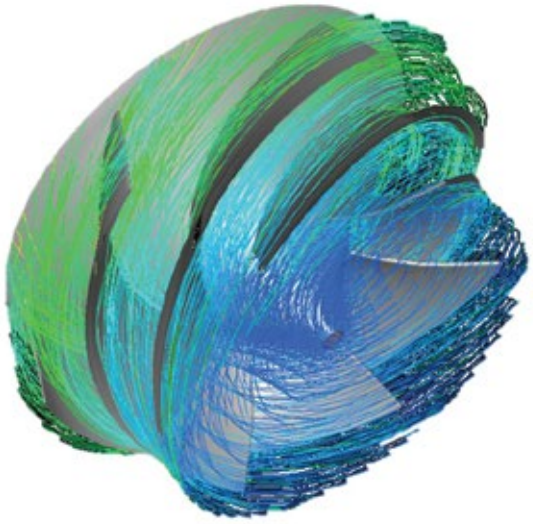
Two different categories of hydrodynamics machines were studied: Axial flow and Mixed flow.

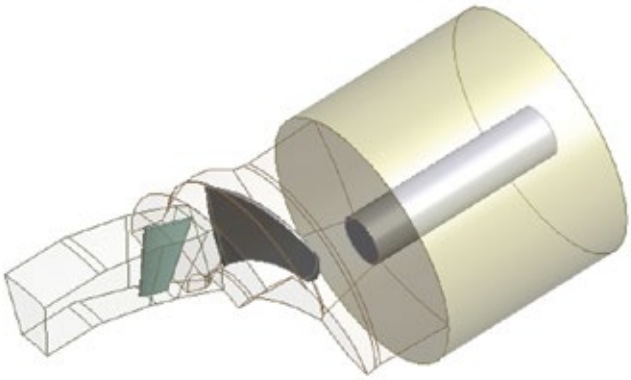
- Use of advanced three - dimensional design methods
- Selection of a computational domain
- Selection of numerical mesh & Computational data utilization
- Numerical solution of flow performance as a pump and as a hydro turbine
- Results analysis

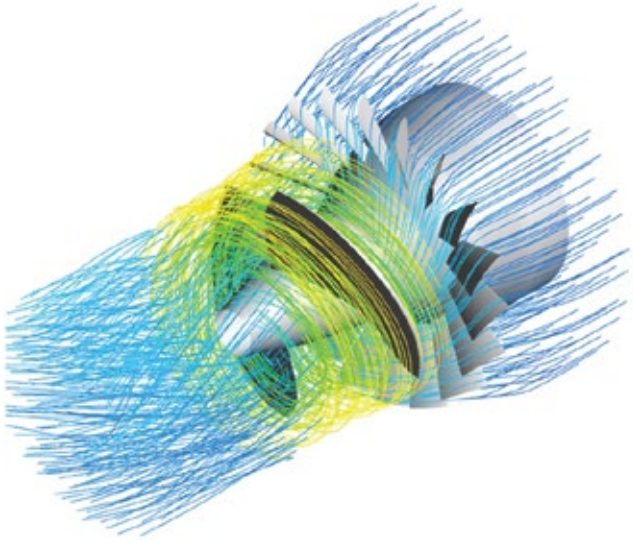
The objective of the parametric investigation of the hydrodynamic design of reversible machines was to quantify the sensitivity of their operational performance (hydraulic efficiency) and their environmental behavior (impact on passing fish) to various key design parameters.

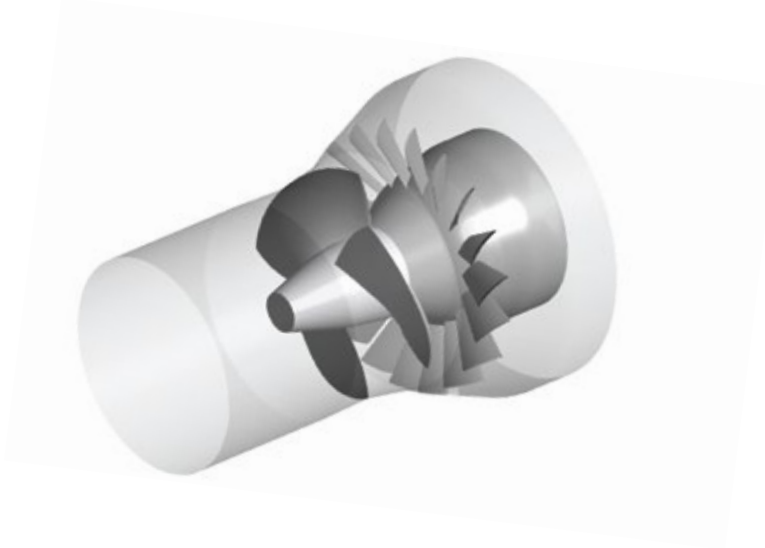
The final selection of the two reversible hydrodynamic machines, axial and mixed flow, was based on the data and results obtained from the parametric investigation and design optimization of the two machines.

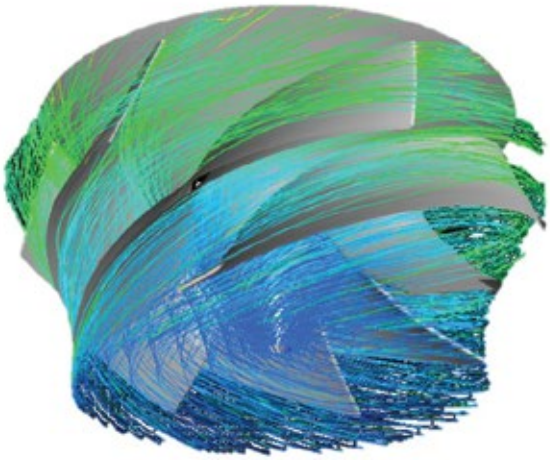


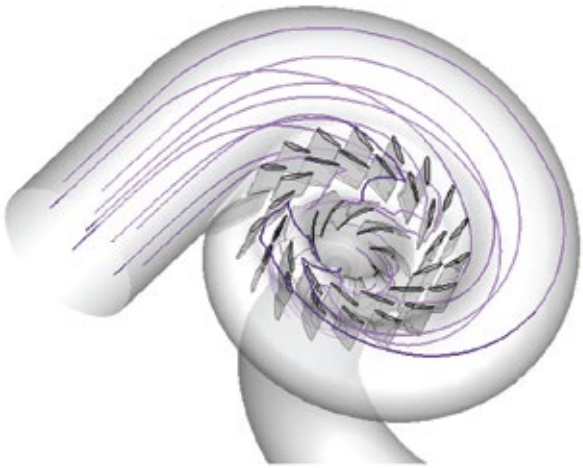


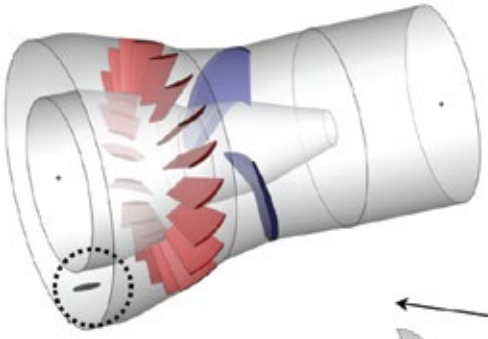


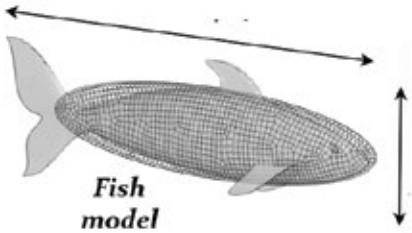












Assessing hydropower fish friendliness and development of an impact index for fish passing

Development of a comprehensive impact index for evaluating the friendliness of hydropower turbines towards fish species

- Fish stressors study
  - Barotrauma, examination on the effects of rapid changes in pressure on fish physiology
  - Cavitation
  - Mechanical Causes, various mechanical factors such as blade impact, abrasion, and grinding are analyzed for their potential to cause fish injury
  - Shear Stress and Turbulence, the study evaluates the impact of shear forces and turbulence on fish
- Evaluation of Existing Numerical Methodologies
- Development of New Numerical Methodology involving the development of a new numerical methodology that incorporates pressure approximation, collision detection of fish with turbine components, and flow analysis
- Simulations replicating fish-turbine interactions under different operating conditions
- Track of the fish prediction and pressure statistics

Mechanical Study and Design

Mechanical study and complete design of the new PAT machines was based on the results of the numerical optimization techniques, considering both their energy efficiency and their impact on passing fish species

- Mechanical study and analysis of strength and friction requirements
- Material selection, applying a sustainable approach to material choices, taking into account environmental impacts and recyclability
- Component design, considering strict construction tolerances and requirements
- Three-dimensional design of machine layouts
- Assembly verification in a three-dimensional design environment and confirmation of studies

Presision Patern Making

Designing precision patterns for casting various metal alloys using modern design and implementation methods.

- Three-dimensional design
- 3D printing
- Utilization of CAM-CAD and CNC Router technology

Machine Construction

Development of a manufacturing methodology and efficient processes for the construction of machines with quality control ensuring high quality and performance.

- Detailed analysis of processes and requirements related to machine construction
- Development of a manufacturing methodology
- Development of a quality control process, precise measurement methods, and analysis for evaluating the quality of produced machines

New Innovative Method for Cavitation Diagnosis

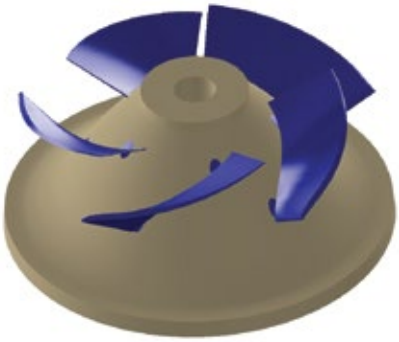
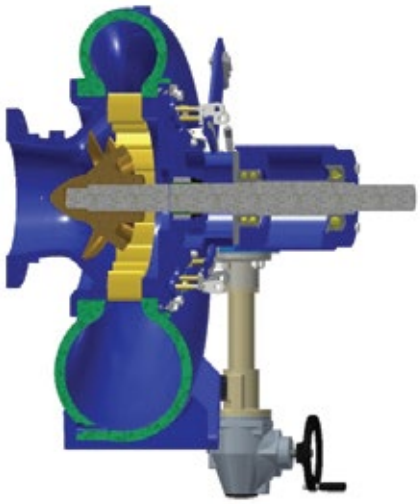
The newly developed innovative method for cavitation diagnosis has the potential to serve as a comprehensive and reliable tool for diagnosing cavitation development on hydrodynamic machinery

- Integrated System (Hardware and Software) for Cavitation Diagnosis in Hydrodynamic Machinery. This system addresses the challenge of detecting cavitation in hydrodynamic machines, which can impact the safe passage of fish species.
- Cavitation Phenomenon Diagnosis before damage occur
- User-Friendly, the system can be used by operators either as a stationary or portable diagnostic tool.
- Applicable to both Pumps and Turbines, the method is applicable to both pumps and hydro-turbines.

Telemetry using IoT

Development of an integrated system for telemetry, enabling remote monitoring of essential measurements in hydro turbines

- New Telemetry Philosophy using IoT, novel approach is proposed, incorporating IoT principles to establish a connected network for data transmission and remote monitoring.
- Integrating microprocessors and sensors into the hydroturbine system to capture and transmit essential measurements such as pressure, temperature, and vibration.
- Advanced software development techniques, such as incremental analysis, are applied to design and implement the telemetry system, ensuring scalability, reliability, and ease of maintenance.
- Python Programming Language known for its versatility, extensive libraries, and ease of integration with various hardware components.
- Remote Visualization of Real-Time Measurements in real-time through internet connectivity, enabling operators and maintenance personnel to monitor hydroturbine performance and quickly identify any anomalies or deviations.






International publications in scientific journals & conferences

Read more publications here: www.hydrovio.gr/el/dimosieyseis

Numerical modelling of fish passage and flow interaction in a hydroturbine

Vibration and acoustic emission monitoring of a centrifugal pump under cavitating operating conditions

Application of Spectral Kurtosis on vibration signals for the detection of cavitation in centrifugal pumps

Numerical design methodology for reversible Deriaz turbine with high energy performance and reduced fish impacts

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