RESEARCH AND DEVELOPMENT - PUMPS

In following sectors

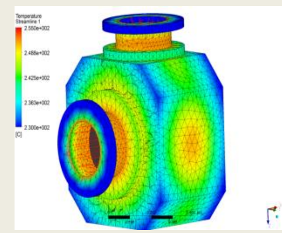
NUCLEAR SECTOR

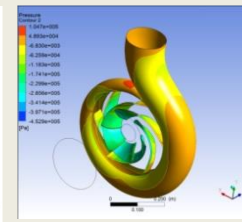
OIL&GAS SECTOR

INDUSTRY

WATER SUPPLY

IRRIGATION





Other activities

SPECIAL PUMPS PRODUCTION

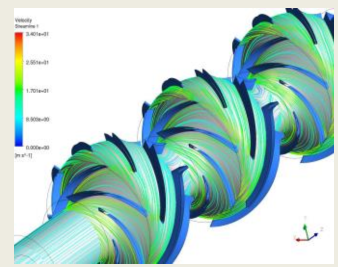
ENERGY SAVING

OPTIMIZATION

REFURBISHMENT

SOFTWARE

TRAINING COURSES



R&D OF HEAVY DUTY PROCESS PUMPS

NUCLEAR POWER PLANTS
OIL & GAS SECTOR
INDUSTRY AND WATER SUPPLY

Design criteria could be selected according to the application

- Nuclear power plant
- Petroleum, petrochemical and natural gas industry.
- Other application

Requirements for pumps for nuclear power plants are very high and very specific. Design criteria should provide high reliability and high performance of the pumps.

API 610, ISO 13709 international standards specifies requirements for pumps for petroleum, petrochemical and natural gas industry.

Requirements for pumps for other application usually consider basic design requirements with some additional requirements.

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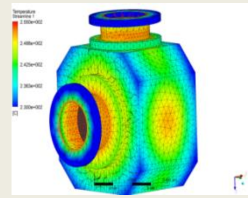
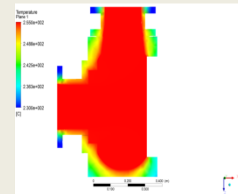
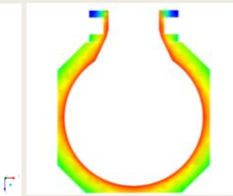
SM PUMPS – DESIGN CRITERIA
Nuclear and Oil & Gas sector

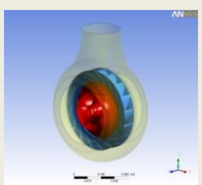
Design Criteria for nuclear Codes and Oil & Gas sector
International Atomic Energy Agency
National Nuclear Energy Commission
US Nuclear Regultory Commission
ASME Code, ANSI Code, ASTM Code
ANSI Code
Hydraulic Insitute Standards
Military standards
American Petroleum Institute Standards

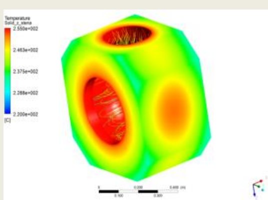


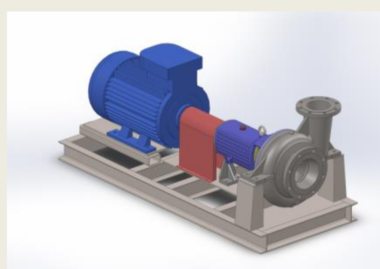




Design Criteria
Basic Hydraulic requirements and conditions for normal operation
Stress limits
Normal operating conditions
Abnormal operating conditions
Emergency conditions
Faulted operating conditions
Pressure - temperature limits
Stress, thermal and fatigue analyze
Relibility characteristcs
Failure Mode and Effects Nanalyzes
Mechanical shock
Seismic Requirements
Flow reate - vibration mode
Flow rate - stability mode
Noise and Acoustic Quieting
Hydraulic Instabilities
Rotor and Rotor Shaft characteristics

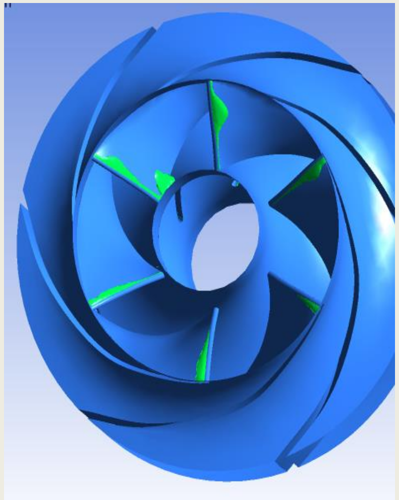


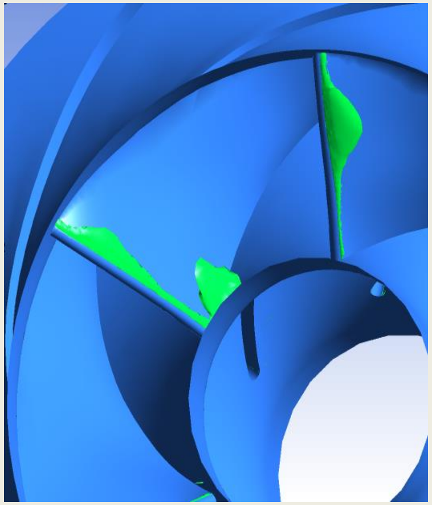


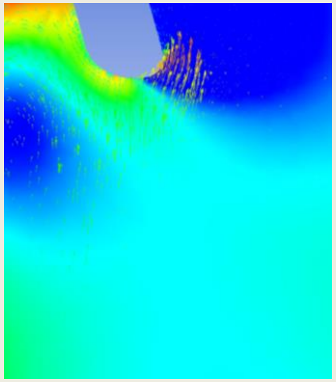


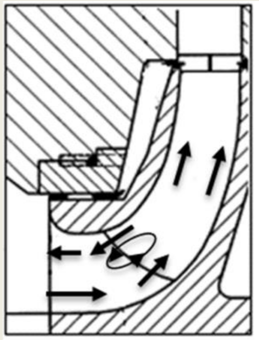
Important criteria analyzes

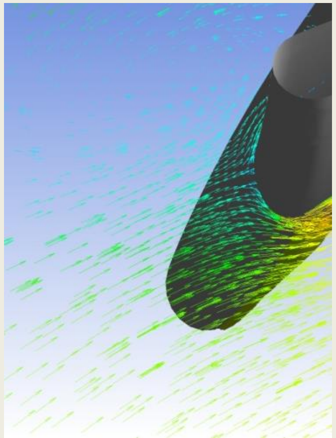
- NPSH – Recirculation free range
- Very important criteria to prevent cavitation at partial flow

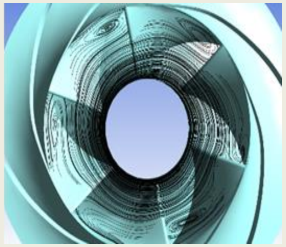




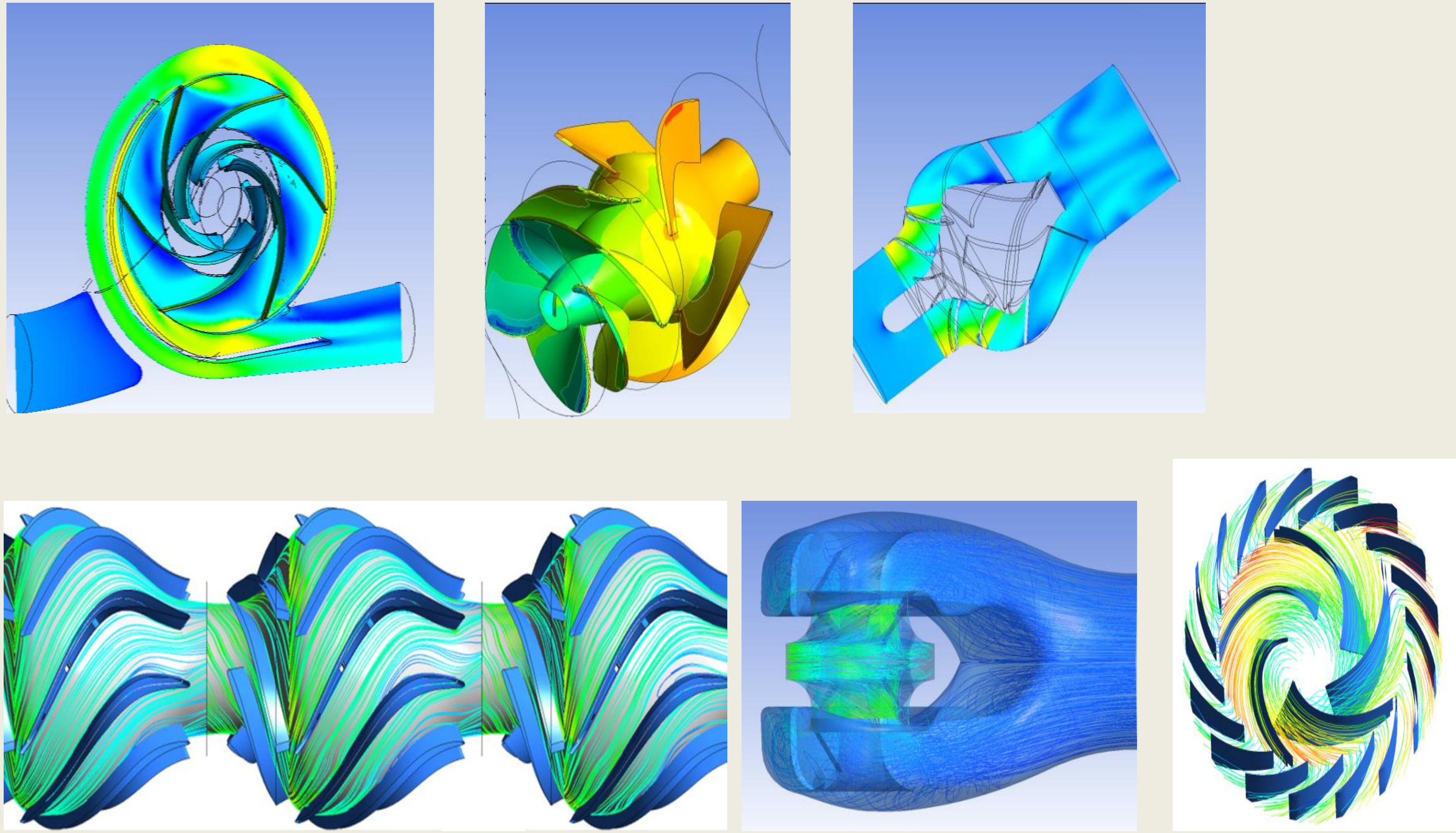




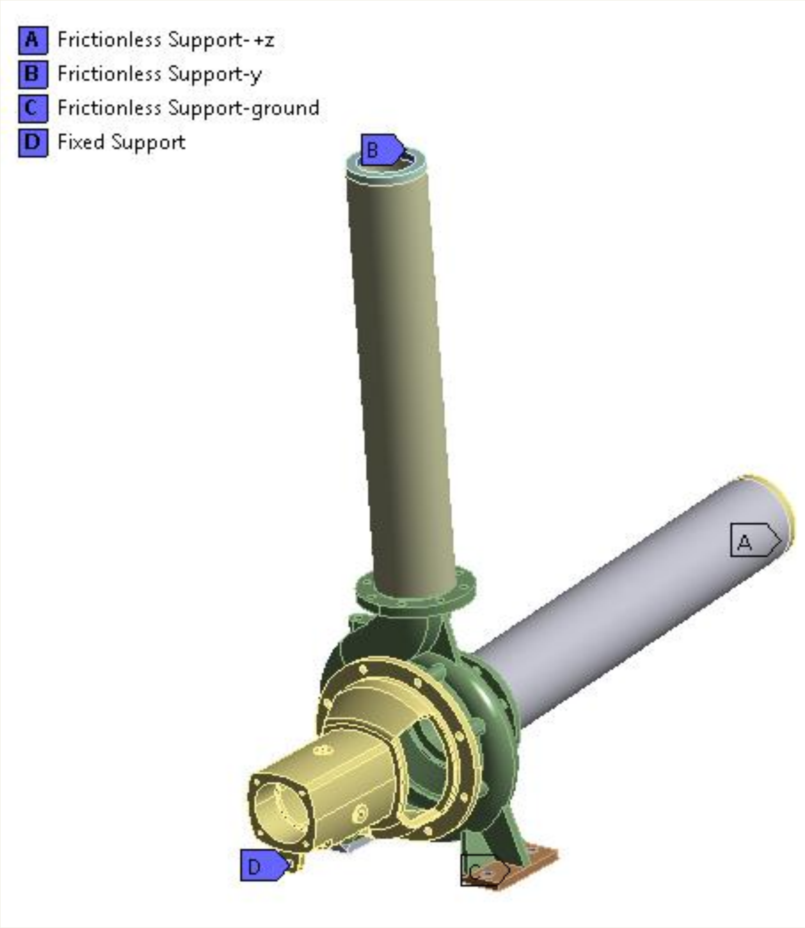




FLOW ANALYZE

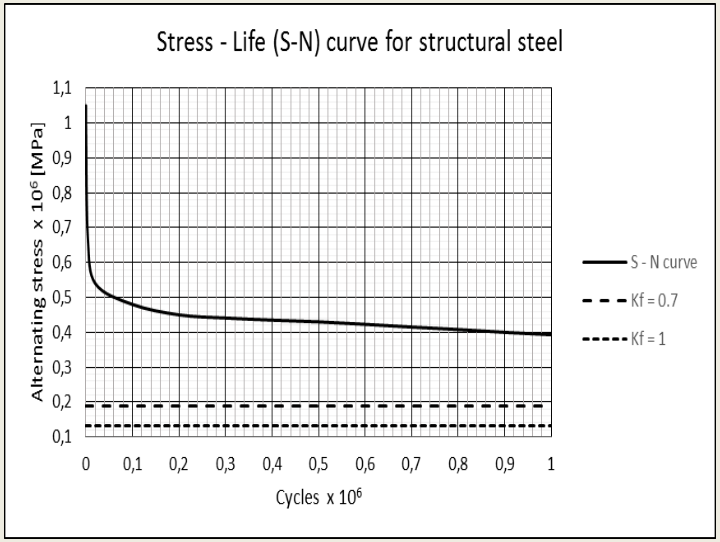


FATIGUE ANALYSIS



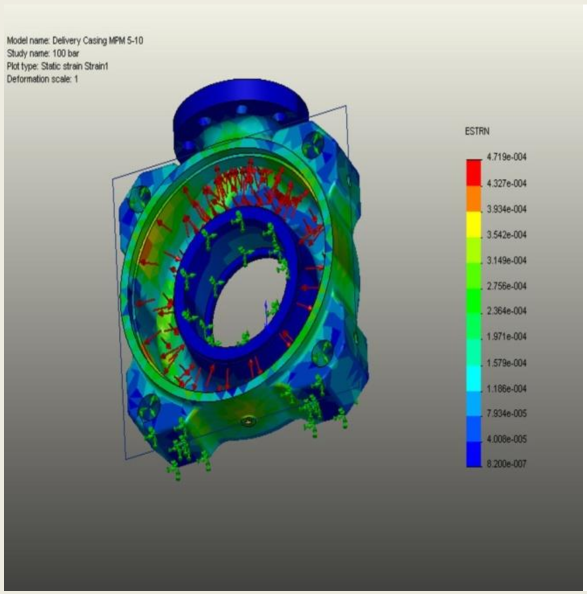
Loading conditions:
Pressure: 10 MPa
Temperature: 400 °C (50 °C/h)

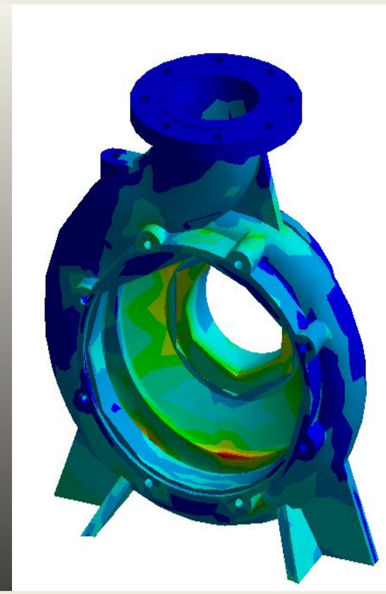
Material properties:
Young's modulus: 200 GPa
Poisson's ratio: 0.3
S-N curve for mean stress equal to 0 MPa (without other influences):

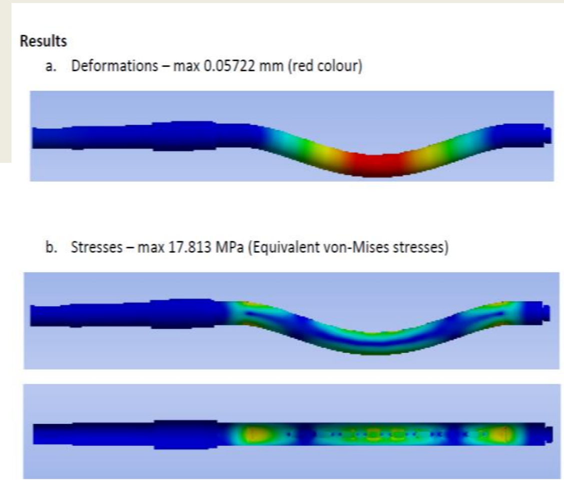


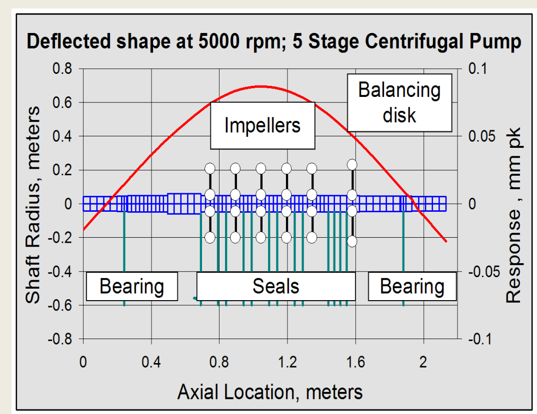
Fatigue calculation: R = 0 and using of Goodman theory

STRESS ANALYZE



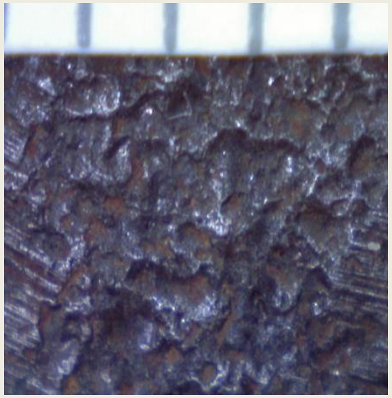


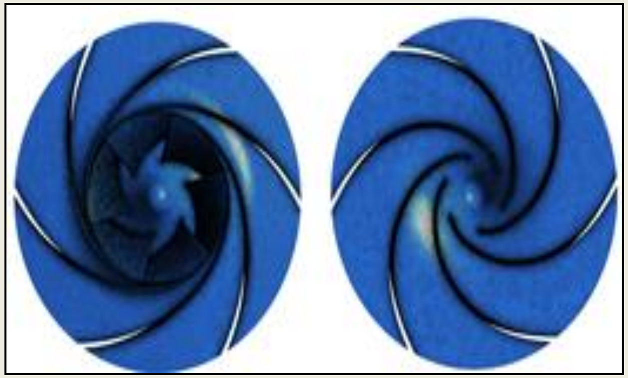


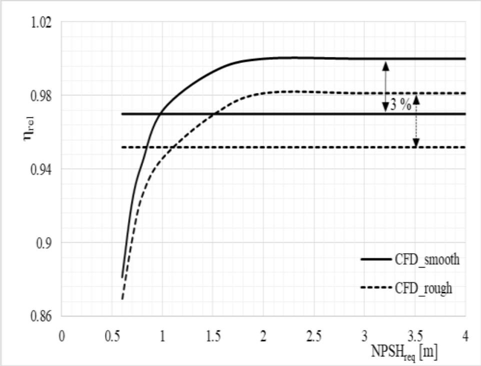


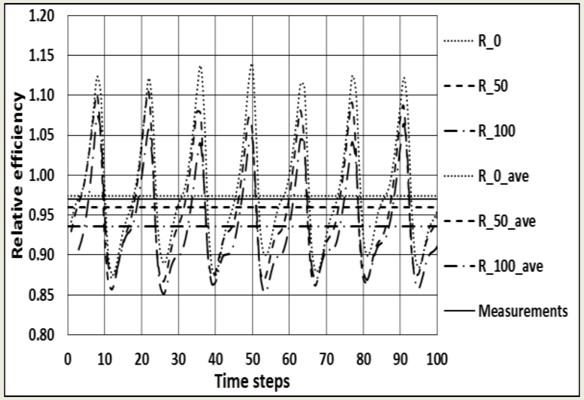
Alternating stress from S-N curve for Infinity-Life Design: 4 MPa

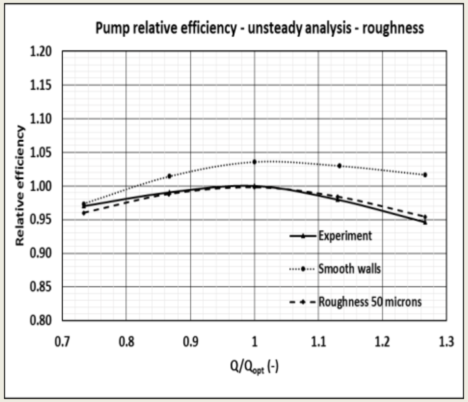
Roughness analyzes – influence to efficiency and NPSH

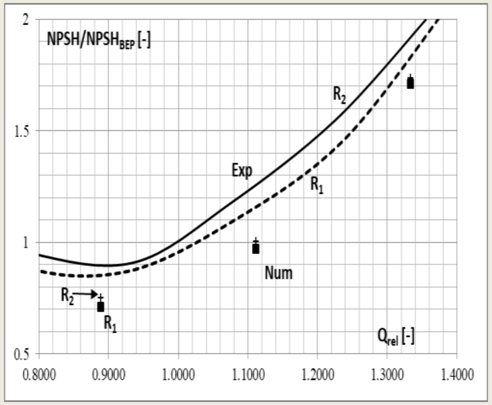












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PUMPS FOR NUCLEAR AND OIL&GAS APPLICATION

DESIGN, REFURBISHMENT AND MAINTENANCE

1. Improving the pumps characteristics

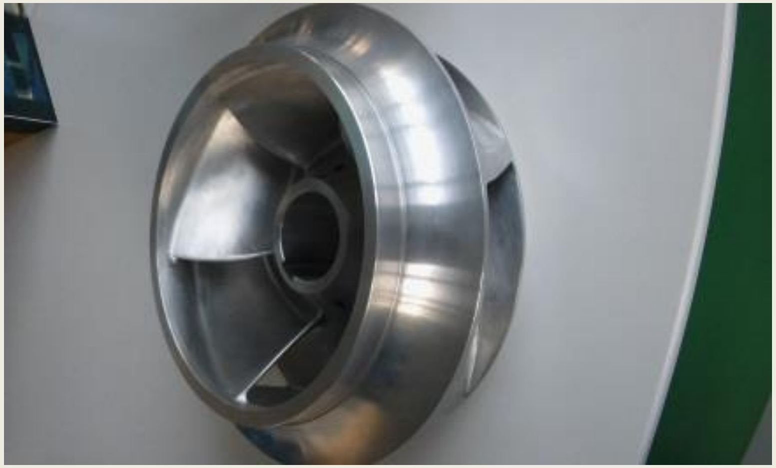
Optimization of the pumps in the systems and energy saving
Efficiency
Cavitation characteristics
Abrasion characteristics
Rotor dynamic characteristics

2. Pumps refurbishment

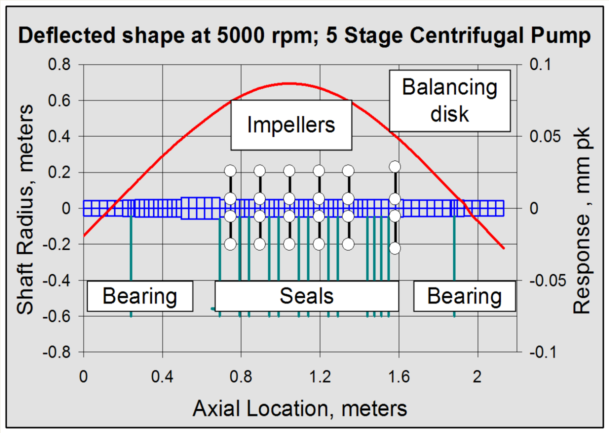
Rehabilitation of existing pumps
Improving the life time of hydraulic parts
Improving the shaft characteristics, vibration, critical speed

3. Customized pump manufacturing

Manufacture pump with same or better characteristics
and dimension as existing pumps
– no need pipelines and foundation modification



Machined impellers from forged solid part
Improving Life time, efficiency, NPSH



Rotor dynamic shaft analyze

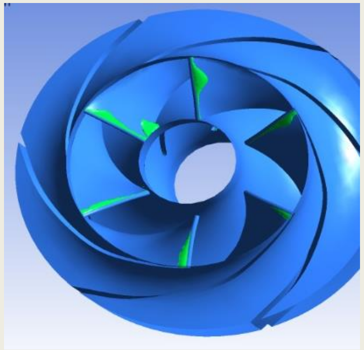
PUMPS FOR NUCLEAR AND OIL&GAS APPLICATION

DESIGN, REFURBISHMENT AND MAINTENANCE

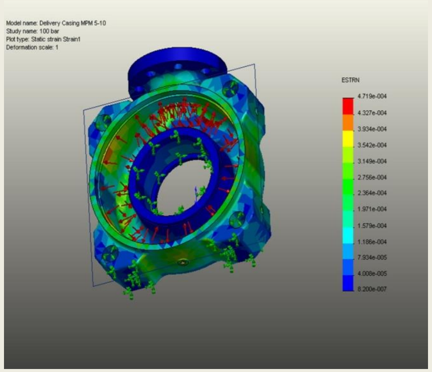
4. Optimization the maintenance expenses

Optimized the maintenances expenses and improving life time of the pumps consider as follows:
pump type
Q –H stability and inclination, flow analyze
NPSH analyze
Structural analyze
Thermal analyze
Fatigue analyze

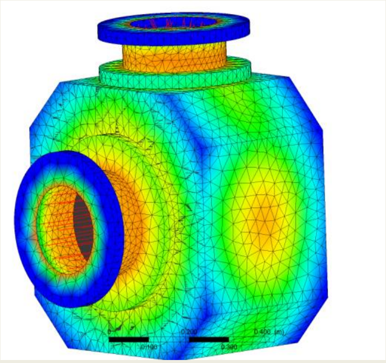
Machined diffuser



Cavitation analyze



Structural analyze



Thermal analyze

Flow analyze

Optimal pump design for system application

Optimal pump design	=	High reliability
		High hydraulic performance (η, NPSH, Q-H stability, wide operating range
		Weight / productional price
		Operating cost, easy maintenance

Optimal pump design for system application

PROPER DESIGN PROCEDURE

Analyze n-NPSHr- η

Analyze operating range and operating conditions

Analyze of required design criteria

Preliminary mechanical design

Preliminary stress and other calculaiton

Choose the hydraulic

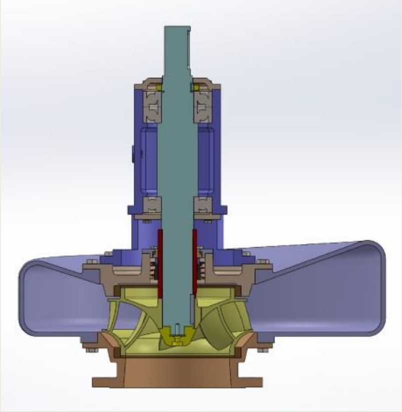
MODEL TESTING

Proving the characteristics of any bigger pump or turbine is possible with model testing. Size of the model depends of the characteristics, but usualy model machine has impeller diamter 300 mm.

Example of model testing:

Project: Conrete water pump Q = 50.000 m3/h, impeller diameter D2= 2200 mm

Model pump impeller diameter D2 = 350 mm



Model pump test rig in Aturia plant in Gessate Italy

Model pump and   impeller

Physical hydraulic model

In many different cases physical hydraulic model is necessary, if the disposition of the inlet piping requires special arrangements, deviating from the guidelines.

Even in the case when the pump-sump design follows the recommendations, model test should be executed if the flow rate per pump is greater than 2,5 m^3/s, or the total flow rate per pumping station is grater than 6,3 m^3/s.

The target of a model investigation is to obtain a sump configuration that can satisfy all the different operating conditions of the plant.

The model has to be geometrically similar to the larger version.

Based on model testing, the local meridional velocity should not deviate from mean velocity for more than ±10%.

Dimension of the model bell should be $D \geq 80$ mm.

Physical hydraulic model

For similarity of flow patterns, the Froude number shall be equal in model and prototype:

$$\frac{F_m}{F_p} = 1$$

In modelling a pump intake to study the potential formation of vortices, it is important to select a reasonably large geometric scale to minimize viscous and surface tension scale effect.

Also, the model shall be large enough to allow visual observation of flow patterns and accurate measurement of swirl and velocity distribution.

Physical hydraulic model

Help to define the dimensions of the intake to minimize viscous and surface tension scale effect.

Viscous effects – Reynolds number (R_e) **$R_e \geq 6 \cdot 10^4$**

$$R_e = uD/\nu$$

Surface tension effects – Weber number (W_e) **$W_e \geq 240$**

$$W_e = u^2D/(\sigma/\rho)$$

ν – kinematic viscosity of the liquid

σ – surface tension of the liquid/air interface

ρ – liquid density

Physical hydraulic model

Acceptance criteria

- **Type of vortex and occurrence time**
  - **Dye core vortices may be acceptable only if they occur for less than 10% of the time.**
- **Swirl angles (swirl meter)**
  - **Average swirl angles (short term - 10 to 30 seconds and long term – 10 minutes) must be less than 5 degrees. Maximum short term swirl angles up to 7 degrees may be acceptable.**
- **Velocities**
  - **Time varying fluctuations in the throat of the bell shall have a standard deviation from time averaged signal of less than 10%.**

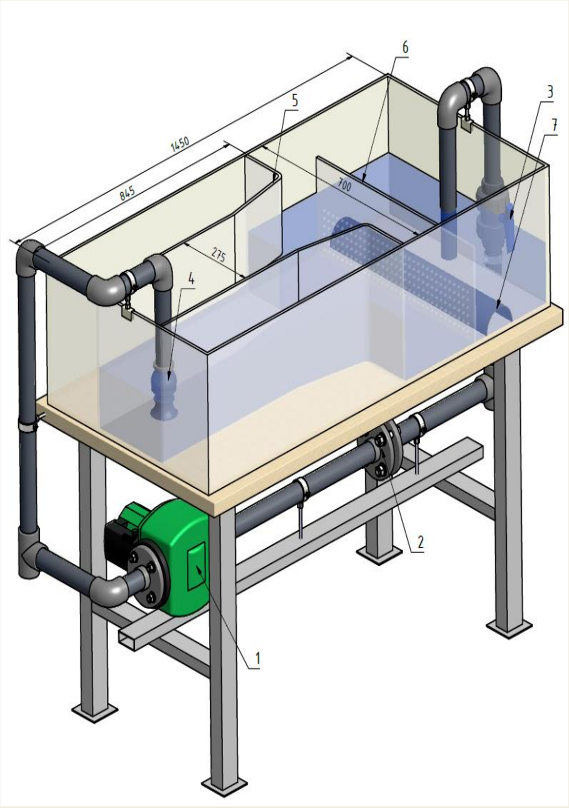
Physical hydraulic model

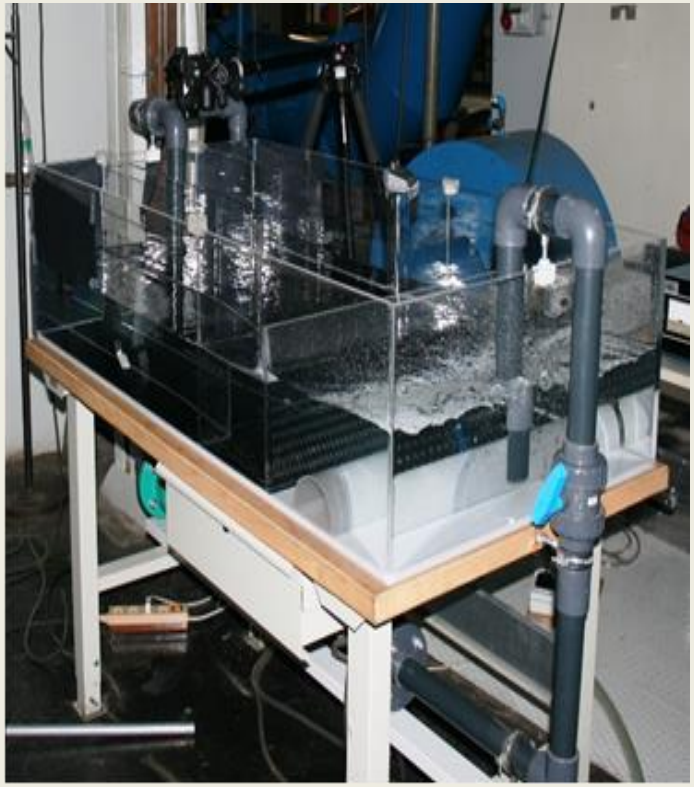
Test plan

- Operating conditions
  - Minimum, intermediate and maximum liquid levels and flows
- For multiple pumps – all possible combinations
- Vortex observations and swirl measurements – for all tests
- Axial velocity measurements at the bell throat or suction inlet – for each pump
- Take photographs or videos
- Report preparation

Physical model – initial geometry

Simple model test case for study of the flow around the open pump sump.





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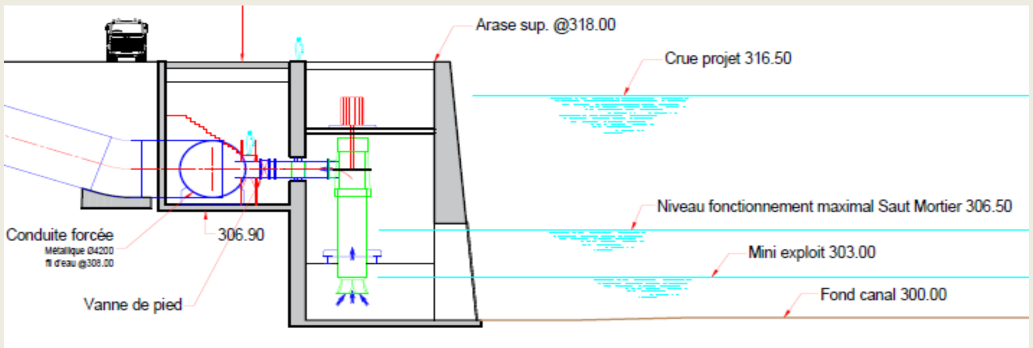
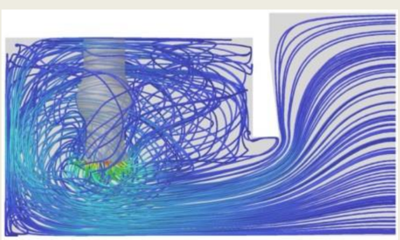
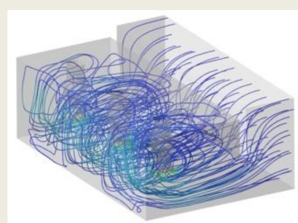
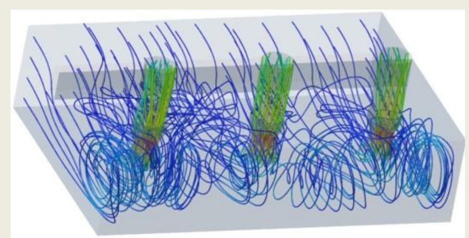
Sample of suction sump CFD analyze

Because of very low min level design of suction sump, CFD analyze is extremely important . Danger of vortexes is very big and it is necessary to make very careful calculation of intake and suction sump.





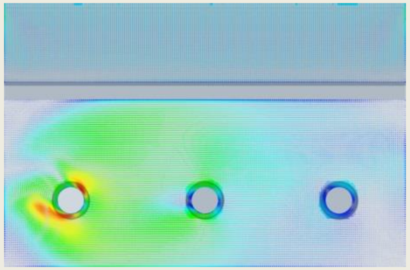


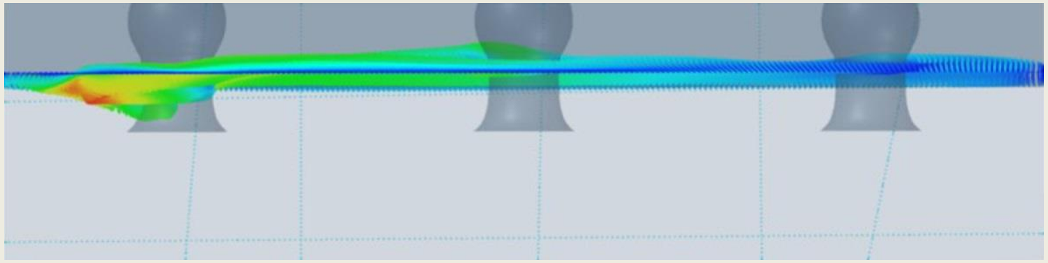


Prelinimary CFD calculation of suction sump and pump intake

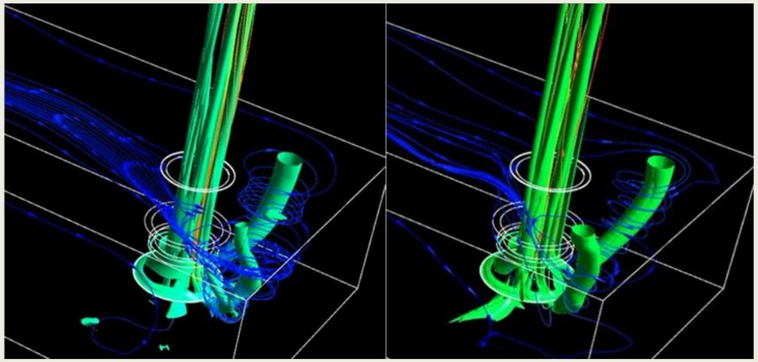
This calculation is done as example – 3 pumps in operation with flow rate of 6 m3/s for each pump

This calculation shows possible intake problems which could caused lower Q-H curve, lower efficiency, higher vibration, worse NPSH characteristics.

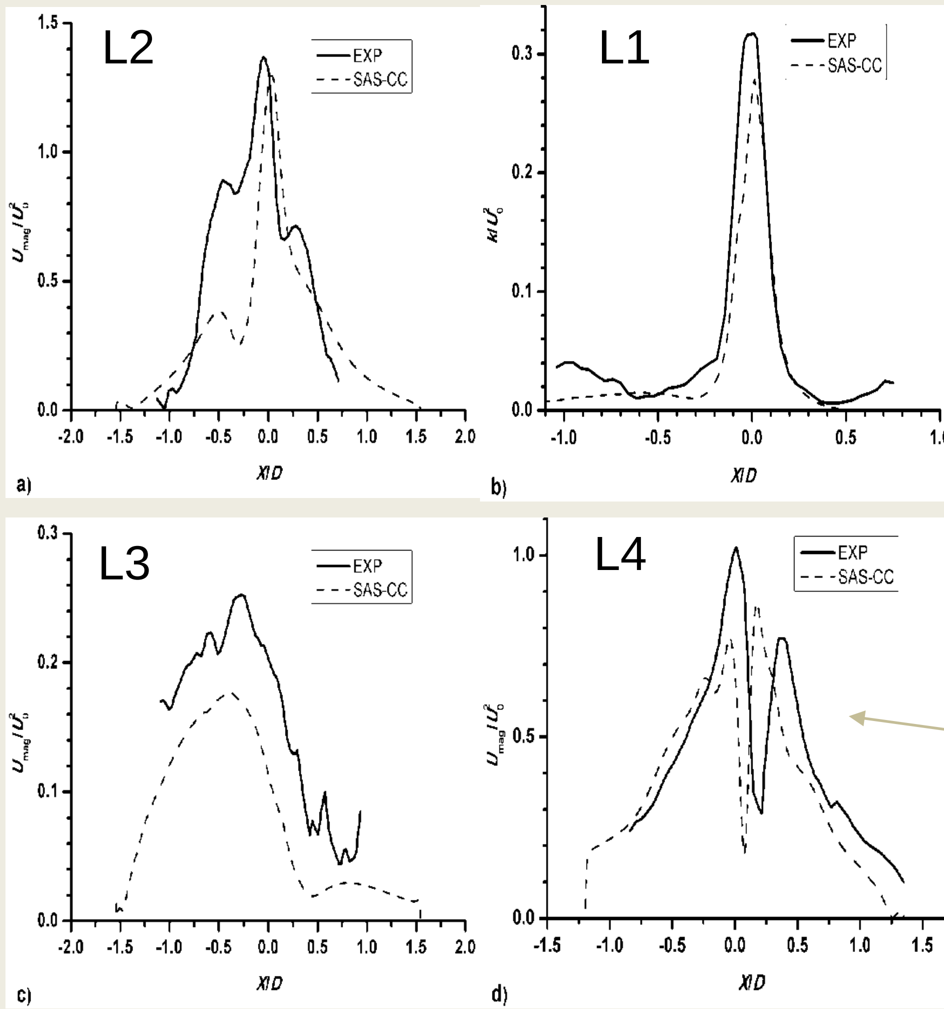


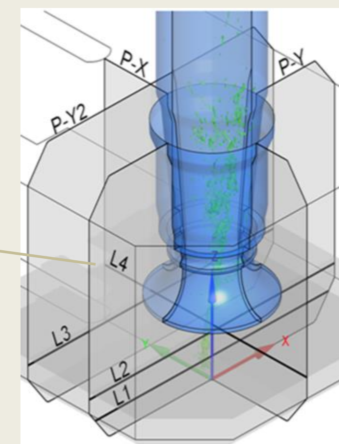


Similar intake problems appear often. Recommendation from literature for sump design are not reliable and additional CFD analyze and model test even for small project is highly recommended.



Comparison between experimental an numerical results





Source CFD: (Škerlavaj, Škerget, Ravnik, Lipej, 2011); Source of experiment: (Tokyay and Constantinescu, 2006)

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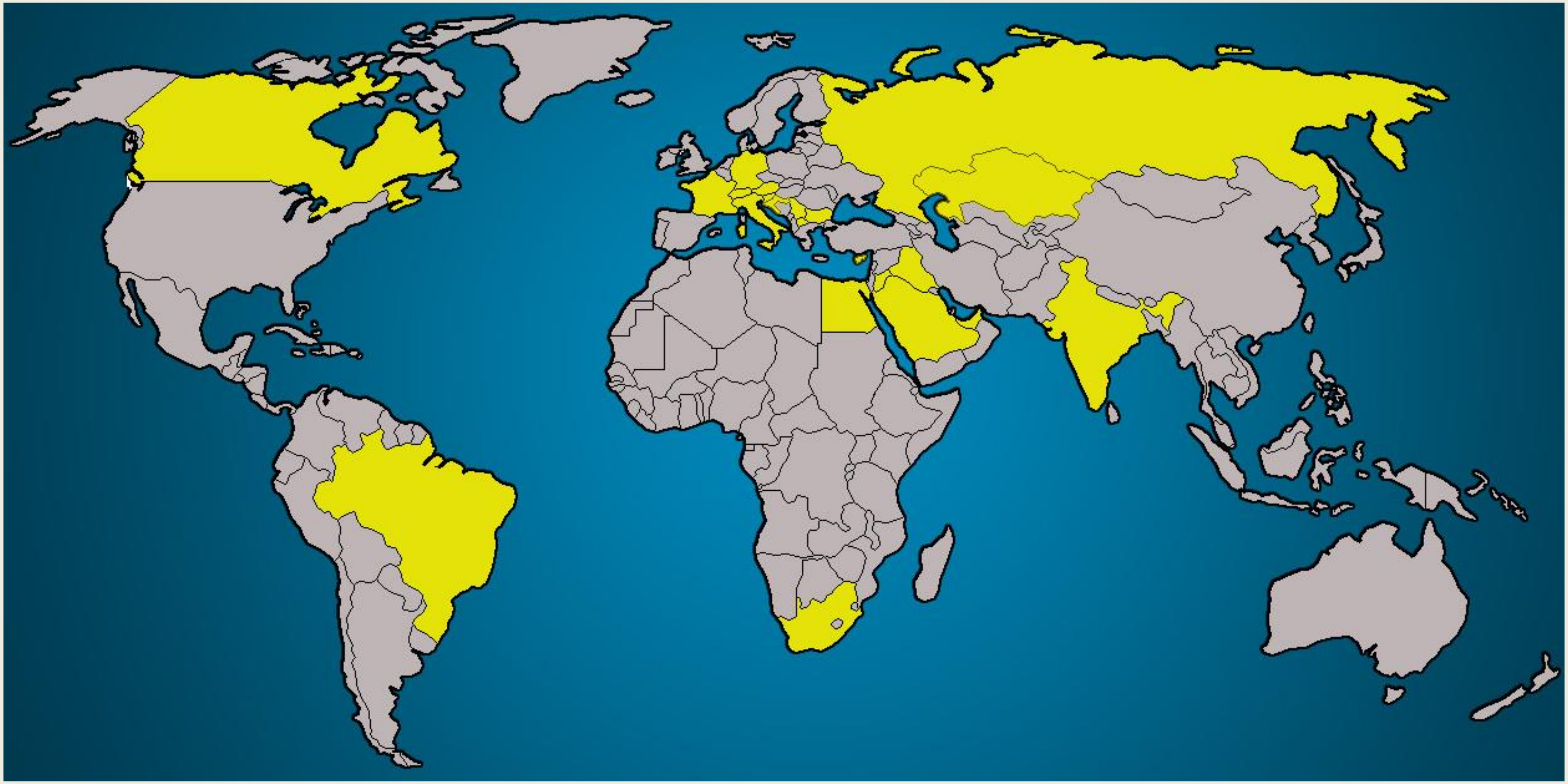
REFERENCES



We have references in 25 countries

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NUCLEAR APPLICATION

R & D

FRANCE	- Reactor cooling pumps
SWITZERLAND	- Reactor cooling pumps
RUSSIA	- II and IV security class cooling pumps
BRASIL	- Model cooling pump

PUMPS

RUSSIA	- II and IV security class cooling pumps

OIL & GAS

R & D

ITALY	- API pumps for Refineries
CANADA	- API pumps for Refineries
BULGARIA	- API pumps for Refineries

PUMPS

RUSSIA - GIDRMAS GERM, ROSSNEFT, GAZPROM

INDUSTRY, WATER SUPPLY, IRRIGATION

GERMANY	- Pumps for Industry
AUSTRIA	- Pumps for Industry
INDIA	- Pumps for water application
ITALY	- Pumps for Industry
ITALY	- Pumps for irrigation
KAZAKHSTAN	- Pumps for industry
SOUTH AFRICA	- Pumps for Mine industry
SAUDI ARABIA	- Pumps for wells
SERBIA	- Pumps for water application
SLOVENIA	- Water hammer systems
EGYPT	- Pumps for water application
IRAQ	- Pumps for water application
JORDAN	- Pumps for water application
CYPRUS	- Pumps for irrigation
RUSSIA	- Pumps for industry
UAE	- Pumps for water application
UKRAINE	- Pumps for industry

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R & D REFERENCES

RUNNING PROJECTS			
1	Sewage pump	Hydraulic and mechanical development	AOI, Ament - Egypt
2	Vertical VS4 API 610	Hydraulical and mechanical development	DHM Russia
3	API 610 BB1 Split casing pump	Hydraluc development	Aturia Italy
4	Vertical Split casing pump	NPSH improving	Aturia Italy
5	Horizontal split casing pump	Hydraluc development	Aturia Italy
6	API 610 OH3 vertical inline pump	Hydraulic and mechanical development	Aturia Italy
PROJECTS 2021			
1	Submersinle 8* pumps	Hydraluc development	Aturia Italy
2	Optimization of pumping station	Energy saving	Rotana Jumeirah Dubai
3	Pump intake CFD analyze	Flow-vortex analyze	Aturia Italy
4	OH 3 8 vertical inline pumps	Hydraulic development	Aturia Italy
5	Split casing pump Q=2800 m3/h	Hydraulic and mechanical development	Aturia Italy
6	API pump type OH 2 nq 12	Hydraulic and mechanical development	DHM Russia
7	Axial vertical pump Q=12000 m3/h	Hydraulic development	Aturia Italy
8	API pump type OH 2 nq 18	Hydraulic and mechanical development	DHM Russia
9	API pump type VS 4 H=410 m	Hydraulic and mechanical development	DHM Russia
10	API pump type OH 2 nq 23	Hydraulic and mechanical development	DHM Russia

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PROJECTS 2020			
1	API BB1 Split casing pump nq 38	Hydraulic development	Aturia Italy
2	Reversible pump-turbine 2500 kW	Hydralic development	Rutschi - France
3	Pump-turbine intake sump analyze	CFD hydraulic development	Rutschi - France
4	High pressure multistage pump nq16	Efficiency improvement	DHM Russia
5	Hydro p0wer plant 3 x 12 MW	3D Model	Hydroing Slovenia
6	Split casing pump nq 33	Hydraulic development	Aturia Italy
7	Split casing pump nq 64	Hydraulic development	Aturia Italy
PROJECTS 2018 - 2019			
1	Pump - turbine 125 MW	Hydraulic development	BHEL India
2	Axial pump Q = 25.000 m3/h	Hydraulic development	Aturia Italy
3	Fire fighting Split casing 250-300	Hydraulic development	Aturia Italy
4	Analyze concrete model pump test procedure		Aturia Italy
5	Submersible 8" pumps	Computational Fluid Dynamic Analyze	Aturia Italy
6	Submersible 6" pumps	Compitational Fluid Dynamic Analyze	Aturia Italy
7	Multistage pump 900 m3/h P = 1.200 kW	Hydraulic and mechanical design	KKR Kazakhstan
8	FM fire fighting vertical pump nq 48	Hydraulic development	Aturia Italy
9	FM fire fighting vertical pump nq64	Hydraulic development	Aturia Italy
10	Multistage horizontal pump nq 28	Hydraulic and mechanical design	CRI India
11	Vertical pump hollow shaft design	Mechanical design	CRI India
12	Fire Fighting Slpit casing pump nq 38	Hydraulic development	Aturia Italy
13	Test rig for pumps	Hydraulic and mechanical design	Napco Algeria

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PROJECTS 2017			
1	Submersible pumps 10"	Hydraulic and mechanical development	Aturia - Italy
2	Vertical pump nq=85, 50.000 m3/h, P=4,8 MW	Hydraulic design	WPIL - India
3	8 Horizontal high pressure pumps range up to 800 m3/h	Hydraulic and mechanical design	CRI - India
4	Training course	Design of heavy duty process pumps	Rutschi -Switzerland
5	Vertical pumps range up to 10.000 m3/h 15 pumps in range	Hydraulic and mechanical design	CRI - India
6	API pump type OH2 nq 12	Improving hydraulic and mechanical design	Aturia - Italy
7	Test rig design for pumps ISO 9906	Hydraulic and mechanical design	Hidroing - Slovenia
8	Axial pump 28.000 m3/h	Hydraulic design	WPIL India
9	Firefighting split casing pump 2500 GPM	Hydraulic and mechanical design	Aturia - Italy
10	Vertical pump nq=46	Improving the hydraulic characteristics	Aturia - Italy
11	Vertical pump nq=38	Improving the hydraulic characteristics	Aturia - Italy
12	Split casing pumps	Mechanical design of 18 split casing pumps	Aturia - Italy
13	Split casing pumps	Re-design of traditional mechanical design	Aturia - Italy
14	Submersible pumps Caprari & Rovatti	Computational Fluid Dynamic Analyze	Aturia - Italy

PROJECTS 2016			
1	Production of prototype of barrel pump for nuclear application	Model pump for testing	Rutschi - Switzerland
2	Development of split casing pumps range of 18 pumps	Hydraulic development, mechanical design	Aturia - Italy
3	Development of split casing firefighting pump nq 34	Hydraulic development	Aturia - Italy
4	Submersible pumps 8"	Hydraulic and mechanical development	Aturia - Italy
5	Development of high pressure barrel pump for nuclear power plants	Mechanical design	Rutschi - Switzerland
6	Split casing pump 150-500	Hydraulic and mechanical development	Aturia - Italy
7	Submersible 6" pumps rage	Hydraulic development and mechanical design	Aturia - Italy
8	Development of split casing pump 200-470	Hydraulic development and mechanical design	Aturia - Italy

PROJECTS 2015			
1	Development of high pressure barrel pump for nuclear power plants	Hydraulic development	Rutschi - Switzerland
2	Development of high pressure pump for electrical motor cooling system integrated in the motor	Hydraulic development	Rutschi - Switzerland
4	Vertical pump design	Hydraulic development	Gidromas Germ - Russia
5	Submersible high pressure pumps	Hydraulic and mechanical design	Intechleader - Canada
PROJECTS 2014			
1	Optimization and energy saving of Water Supply System Velika Plana	New pumps and new operating regimes	Velika Plana - Serbia
2	Thermal calculation of pump casing for nuclear power plant	Heat transfer calculations	Rutschi - Switzerland
3	Submersible pump for nuclear power plants	Improving the hydraulic characteristics	Aturia - Italy
4	Test rig for pumps Q max 5.000 m3/h	Design	NWWC - Saudi Arabia
6	End suction pumps	New pumps Q = 1400 m3/h H=20 m	Godent - Serbia
7	Horizontal pumps	Production of impellers and diffusers	Rutschi - Switzerland
8	Electrical motor cooling pump	Hydraulic development	Rutschi - Switzerland
9	Water turbines test rig design	3D and 2D design	Hidroing - Slovenia

PUMPS PRODUCTION 2018-2022

	Item, Customer	Quantity	Description
1	Model pump Nuclear Power Plant, Rutschi – Switzerland	1	Development and production
2	Vertical turbine pumps TSVA-1200-55, Rosenergoatom, Kalininskaya Nuclear power plant – Russia	4	Development and production Q = 1200 m^3/h, H = 55 m, P = 250 kW IV Safety class
3	End suction pumps TSNA 100/50 Rosenergoatom, Kalininskaya Nuclear power plant – Russia	3	Development and production Q = 100 m^3/h, H = 50 m, P = 22 kW III Safety class
4	High pressure multistage pumps Rosneft refinery – Russia	2	Development and production Q = 180 m^3/h, H = 425 m, P = 315 kW
5	Split casing pumps Rosenergoatom, Leningradskaya Nuclear Power plant – Russia	6	Development and production Q = 1250 m^3/h, H = 125 m, P = 550 kW II Safety class
6	Twin screw pumps for masut Transneft, Novorossiysk – Russia	2	Q = 28 m3/h p= 50 bar P = 75 kW
7	Condensate vertical pump ELEM - Macedonia	1	Q =540 m3/h, H = 75 m
8	Sewage submersible pumps Waste Water Treatment Plant Dojran Macedonia	3	Q = 750 m3/h, H=16 n
9	Vertical pumps GODENT – Serbia	2	Q = 540 m3/h, H=75 m

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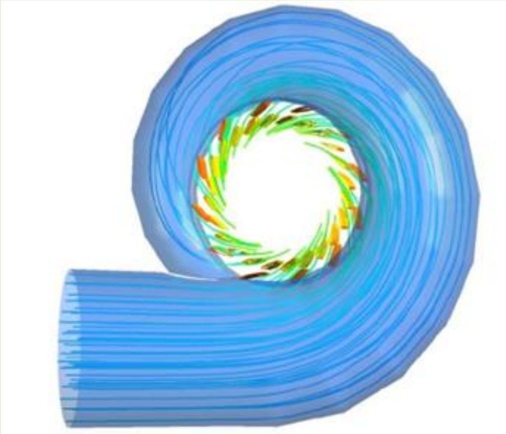
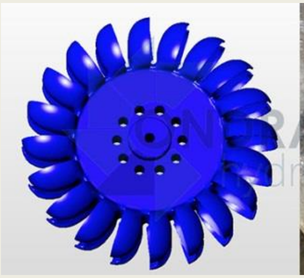
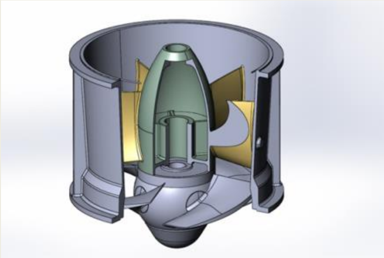
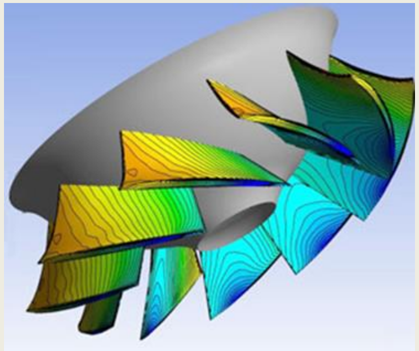
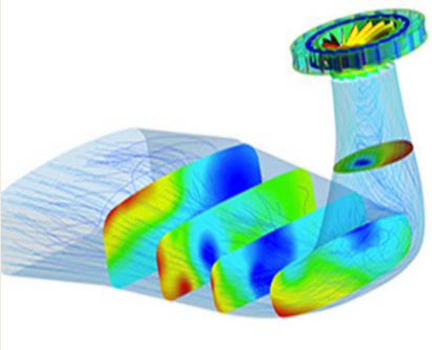
RESEARCH & DEVELOPMENT
REVERSIBLE PUMP-TURBINES
TURBINES









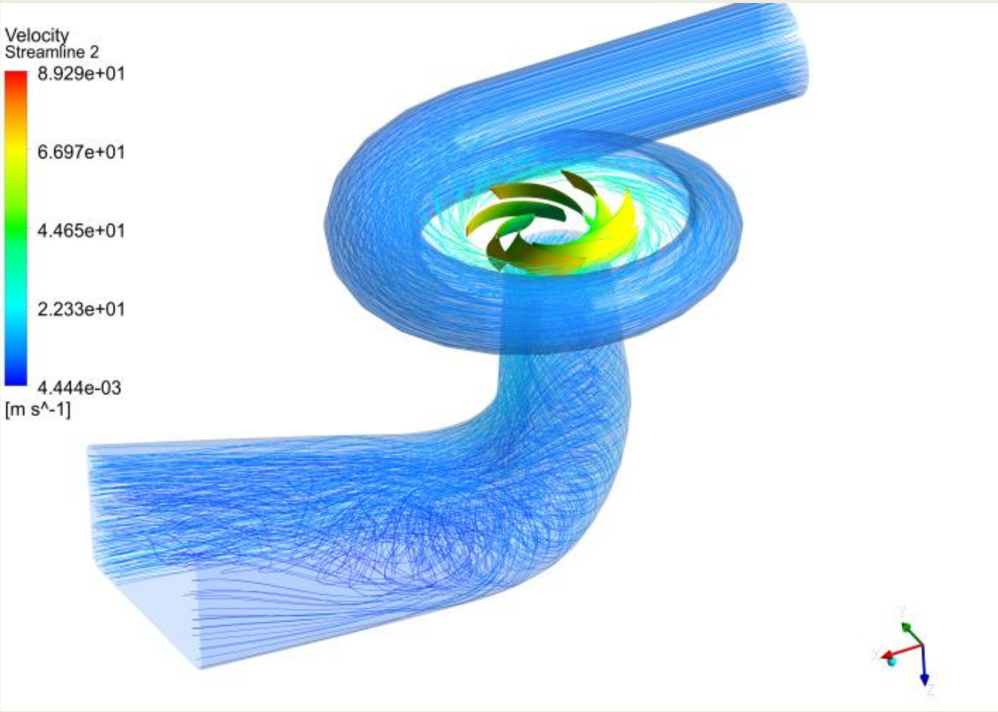


REVERSIBLE PUMP-TURBINE REFERENCE

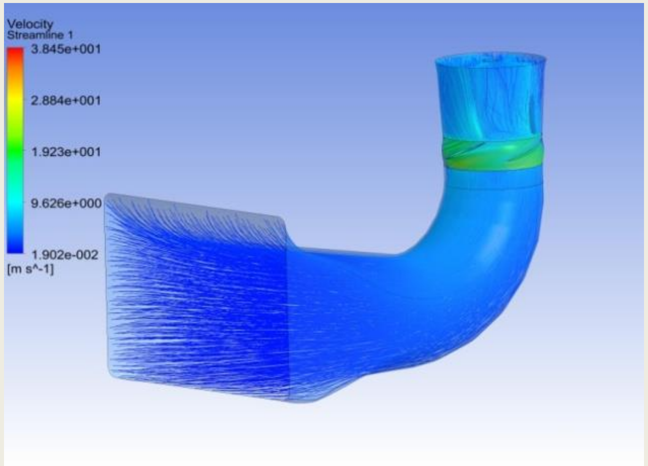
BHEL Bhopal – INDIA

Reversible pump-turbine
Design of hydraulic
Preliminary mechanical design

Q = 45 m3/s, (162.000 m3/h)
H = 236 m,
P = 125 MW



REVERSIBLE PUMP-TURBINE REFERENCE



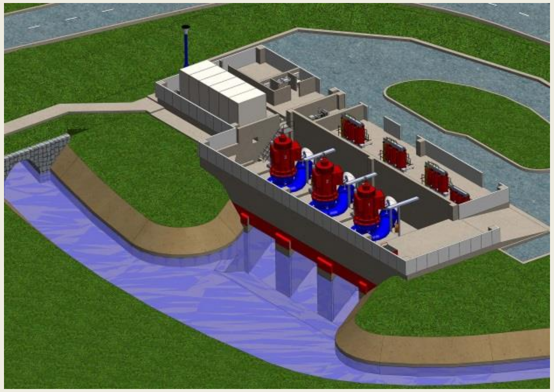
GIDROMASH – RUSSIA

Reversible pump-turbine
Design of hydraulic and mechnical design

Q = 12.000 m3/h
H = 8 m,
P = 360 kW

Small Hydro Power Plants		
Power Plant	**Country**	**Power [MW]**
Mesici Nova	Bosnia and Hercegovina	3 x 1700 kW
Godent	Serbia	1 x 250 kW
Lipkovo	Macedonia	1 x 900 kW

Runner HE LIPKOVO 900 kW



MHE Mesici Nova 3 x 1700 kW

SM PUMPS references				
Pos.	Projects	P MW	Company	Country
1	Pump - turbine	125	BHEL	INDIA
2	Pump - turbine	0,36	Gidromas	RUSSIA
3	Concrete cooling pumps	4,245	Aturia - WPIL	Italia - India
4	Hydro power plant Mesici Nova	5,1	Hidroing	Slovenia - BIH
5	Hydro power plant Lipkovo	0,9	Vodostopanstvo	Macedonia

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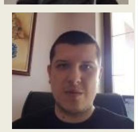
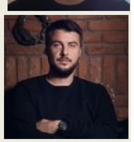
KEY PERSONNEL

SM PUMPS SLOVENIA

	Name and surname	Experience	Specific professional experience
	B.Sc. DUŠKO MITRUŠEVSKI	38	Specialized for hydraulic and mechanical design for special pumps and water turbines, Energy efficiency analyzes in pumping systems and processes
	Ph.D. ANDREJ LIPEJ	33	Specialized for computational fluid dynamic, heat transfer calculation, fatigues calculation
	Ph.D. BOŠTJAN ZAFOŠNIK	23	Specialized for FEM analysis, structural analysis, stresses, displacement, fatigue and fracture mechanics.
	Ph.D. IVANA LUKEC	16	Specialized for application of mathematical modeling and simulation in process industry, specially refining, with the process optimization as the main objective
	Ph.D. ZORAN SPIROVSKI	25	Specialized in computational fluid dynamic, stress calculation
	M.Sc. HORYMIR ONDRACKA	34	Specialized for hydraulic design in turbine regime, CFD analyze expert
	B.Sc. SREČKO MITRUŠEVSKI	12	Specialized for hydraulic and mechanical design for special pumps and water turbines, computation fluid dynamic
	B.Sc. SAŠO MITRUŠEVSKI	10	Marketing project manager, marketing research analyzes
	B.Sc. FILIP DIMČEVSKI	12	Head of software engineering. Innovative engineer with over 10 years’ experience. Specialized for software engineering, data structure design and complex digital projects.

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SM PUMPS
SLOVENIA

IQNet
THE INTERNATIONAL CERTIFICATION NETWORK

CERTIFICATE

Cro Cert has issued an IQNet recognized certificate that the organization:

SM PUMPS development and production
of hydraulic machines Srećko Mitruševski s.p.
Ul. Milana Majcna 18
1000 Ljubljana, Slovenia

has implemented and maintains a

Quality Management System

for the following scope:

Mechanical Engineering: development, construction and production of diferent types of pumps,

which fulfils the requirements of the following standard

ISO 9001:2015

Issued on : 2019 - 12 - 19
Expires on : 2022 - 12 - 18

This attestation is directly linked to the IQNet Partner's original certificate and shall not be used as a stand-alone document.

Registration Number : HR - 611

Alex Stoichitoiu
President of IQNet

Damir Sučić
General Manager of Cro Cert

Cro Cert

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** The list of IQNet partners is valid at the time of issue of this certificate. Updated information is available under www.iqnet-certification.com

12 months after the issuing date, validity of this certificate should be verified by sending written inquiry to cro.cert@cro-cert.hr