Design and investigation of pump-turbine models for heads of 80-500 m

Yuri Bykov, Oleg Khoryev, Anton Panov

Anatolii Pidhornyi Institute of Power Machines and Systems of the National Academy of Sciences of Ukraine

Promising hydraulic power plants and pumped storage plants in Ukraine

CHERVONOOSKILSKA PSP	84 m
TASHLYK PSP	86 m
KANIV PSP	95 m
LOMACHYNSKA PSP	125 m
DNIESTER PSP	162 m
CARPATHIAN HPP	200-500 m

Total capacity

	2022	2024
Hydropower, MW	6 662	2 950
Pumped storage, MW	1 839	1 700

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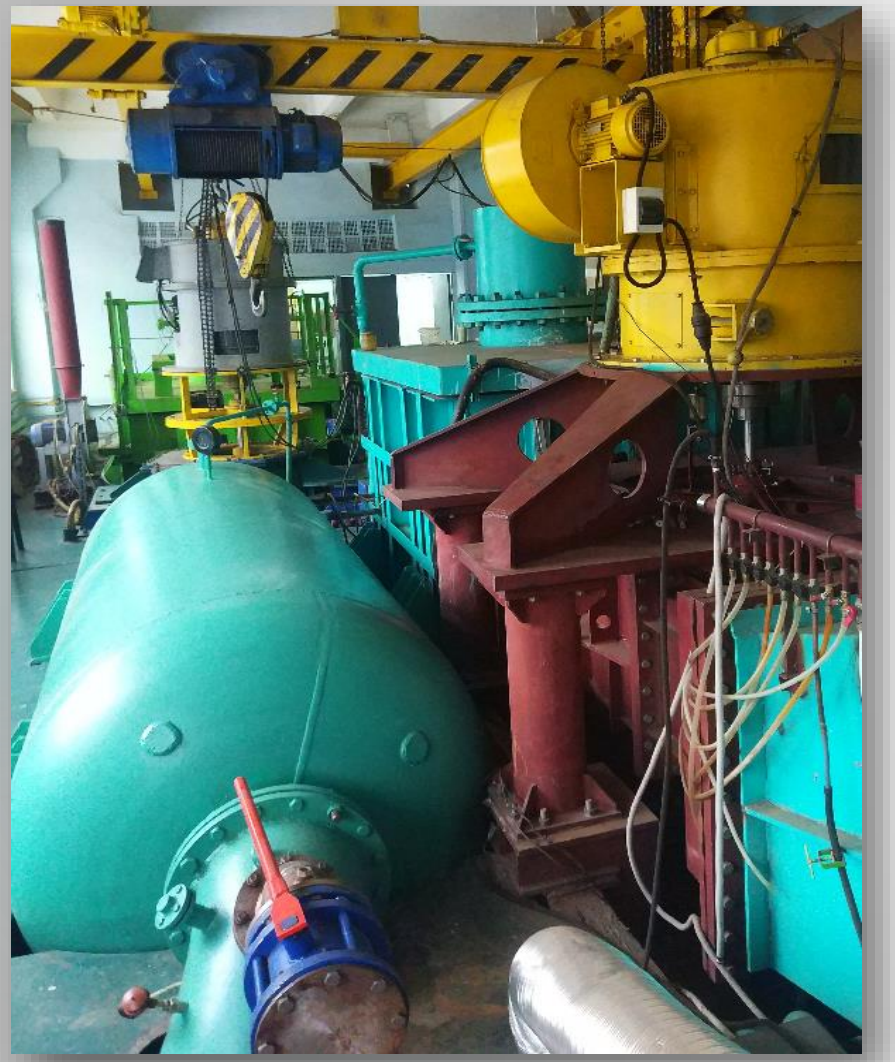
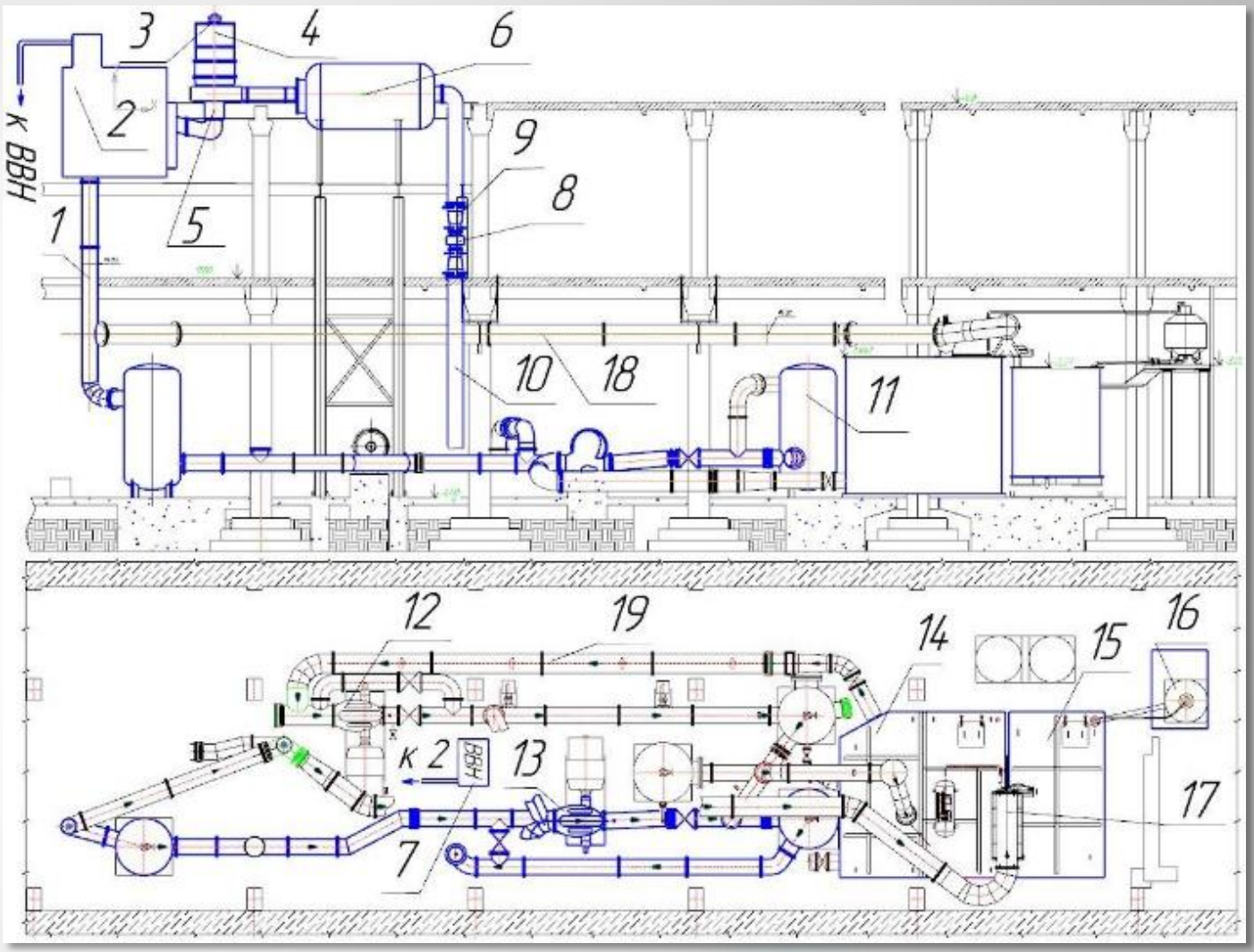
Hydrodynamic test stands





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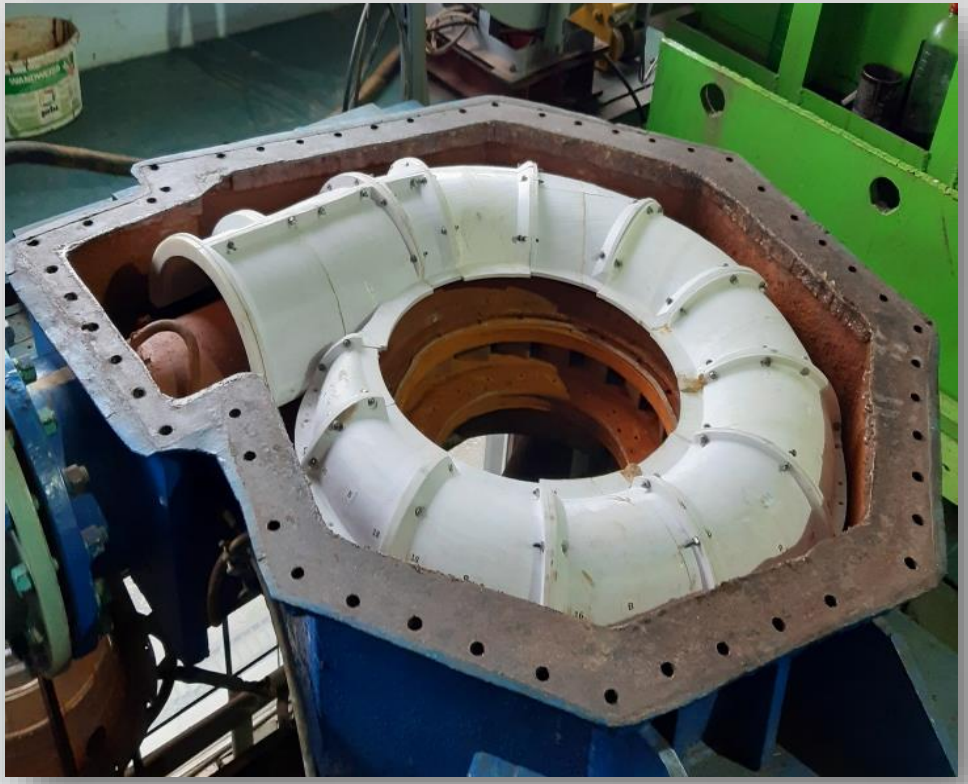
Hydrodynamic test stands



Model block, spiral casing, and runner of a high-speed pump-turbine model

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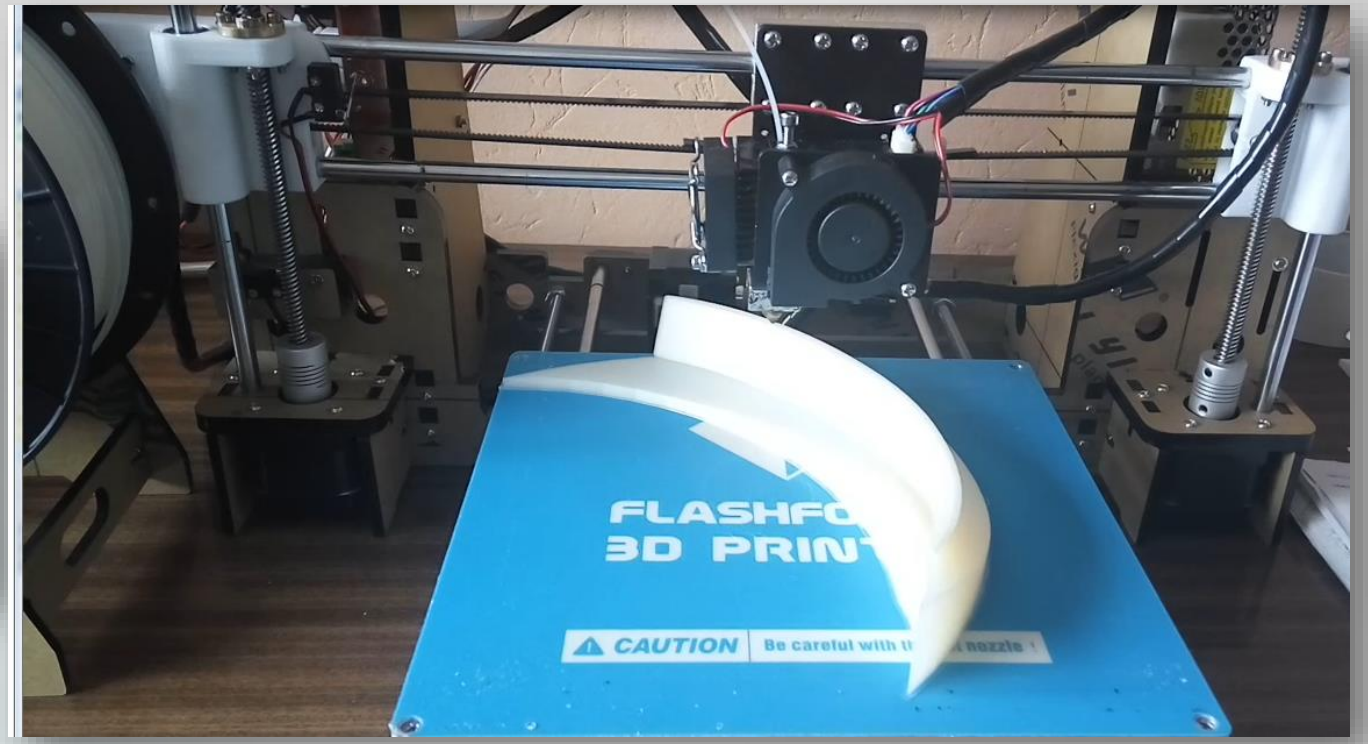
Manufacturing of runner blades on a 3D printer



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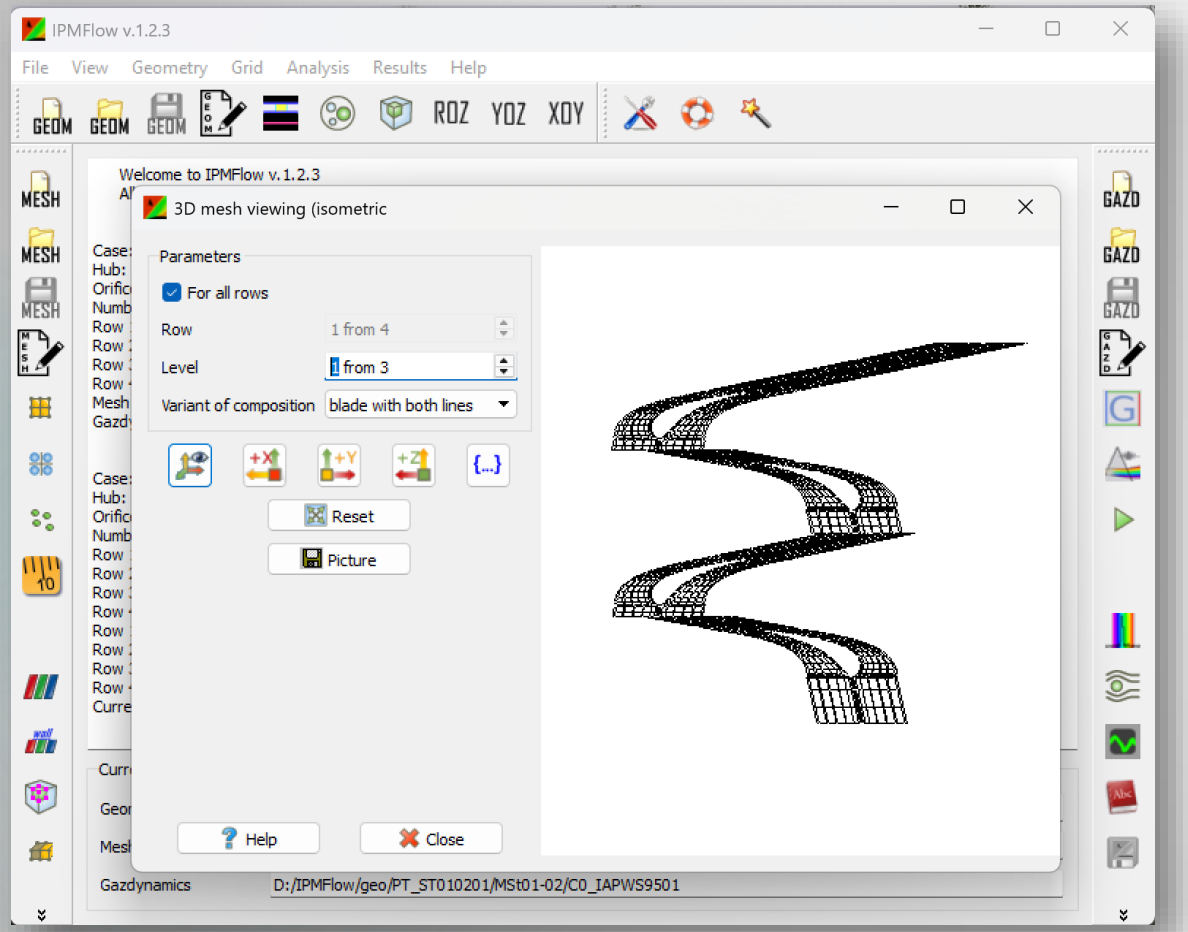
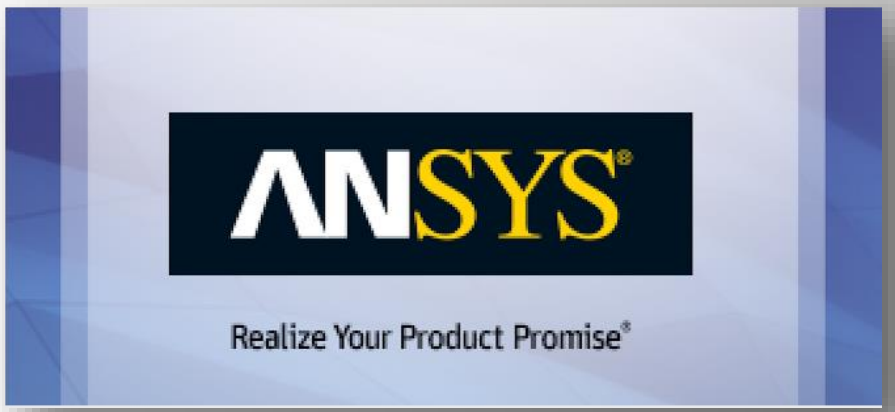
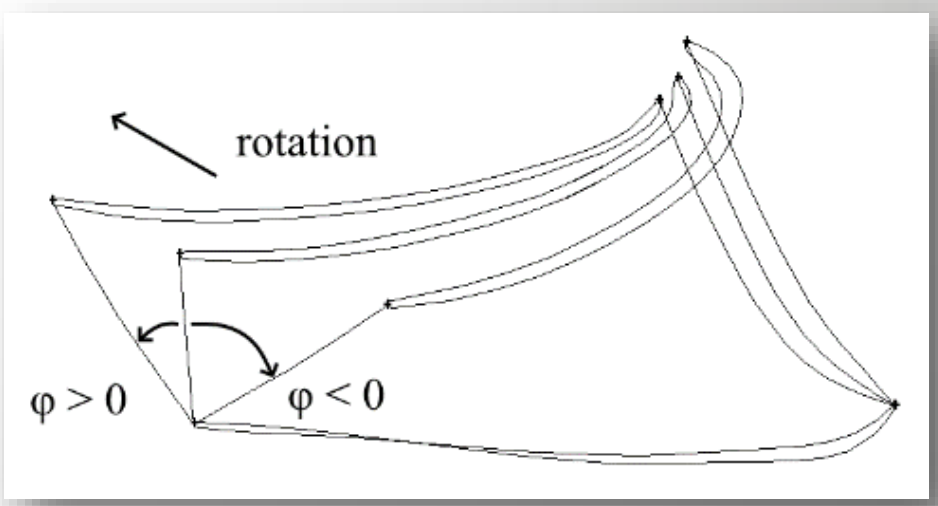
CFD tools





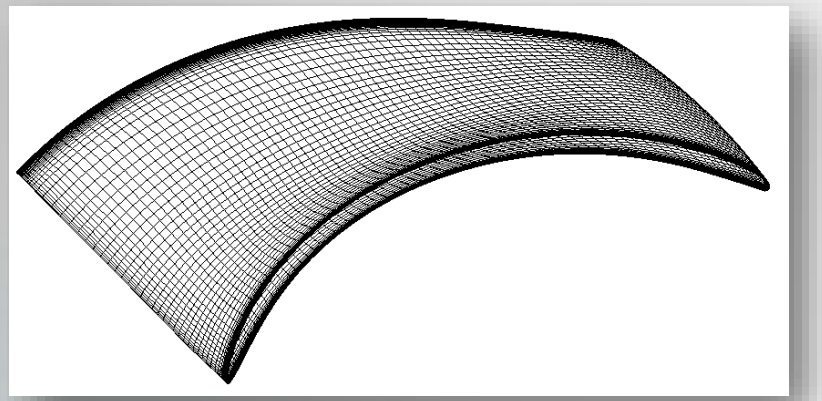
Runner blade lean

GE Energy's
X-Blade

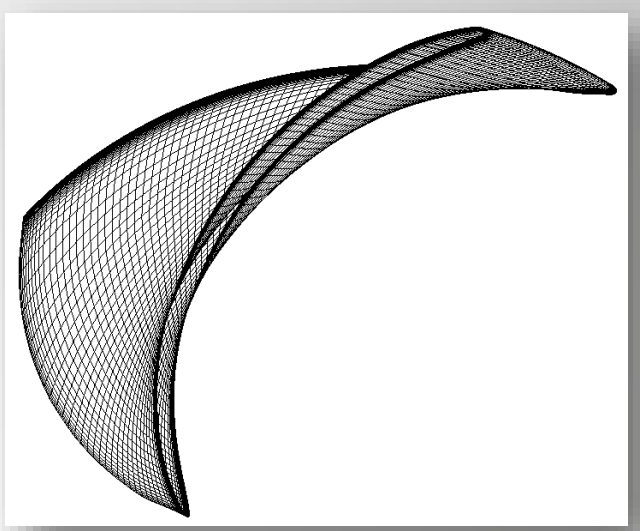


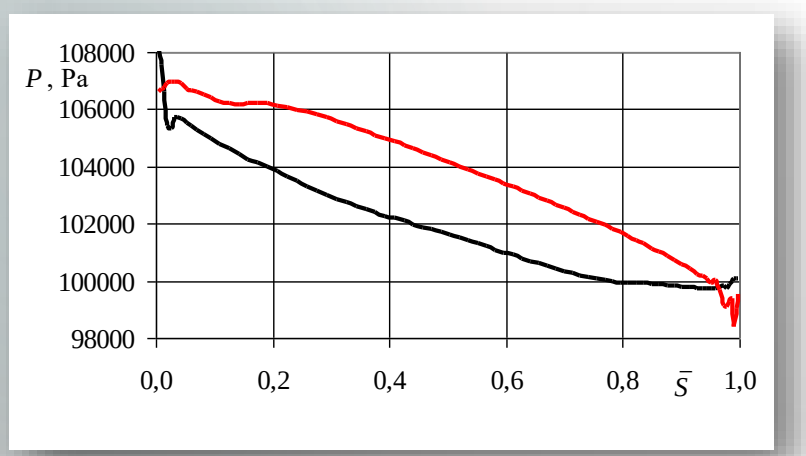
Runner of pump-turbine for heads of 80-120 m

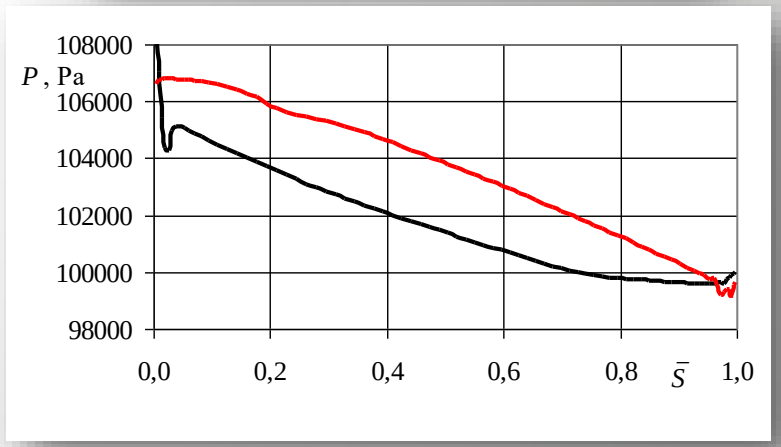
R5249



R5249M30



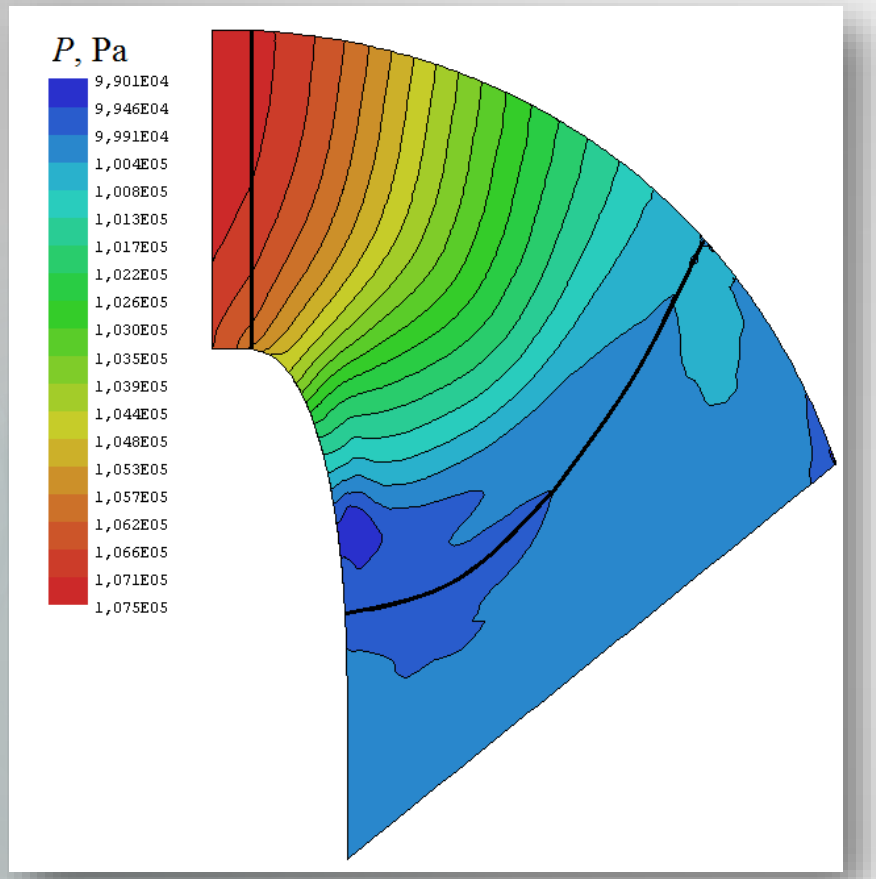




Pressure distribution in midspan

Runner of pump-turbine for heads of 80-120 m

R5249



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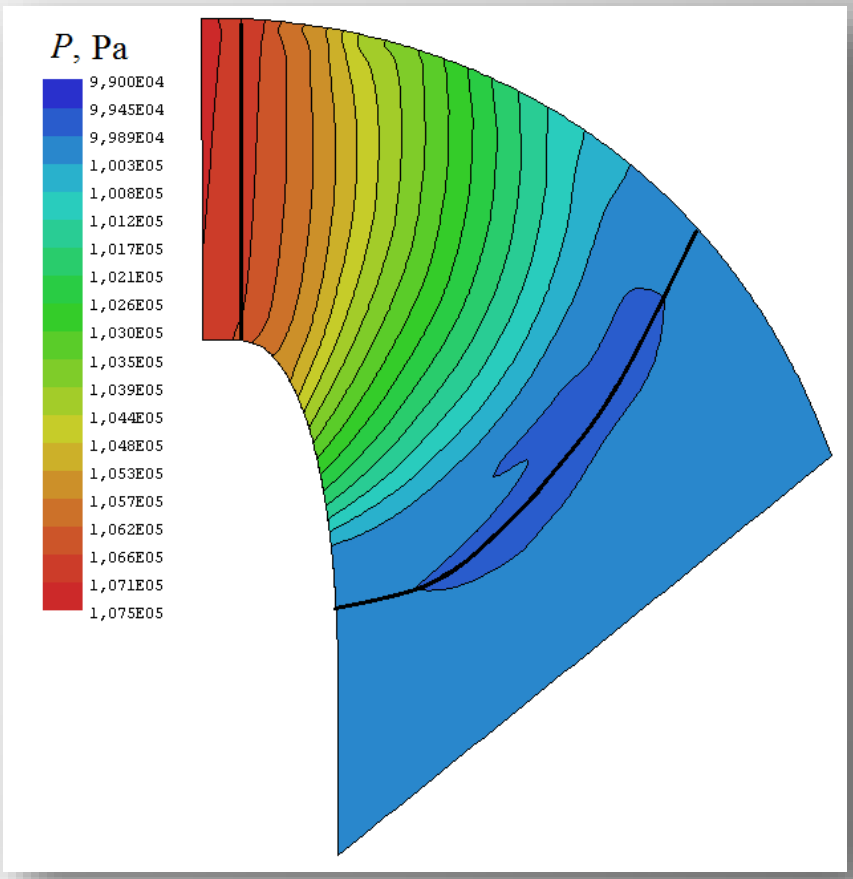
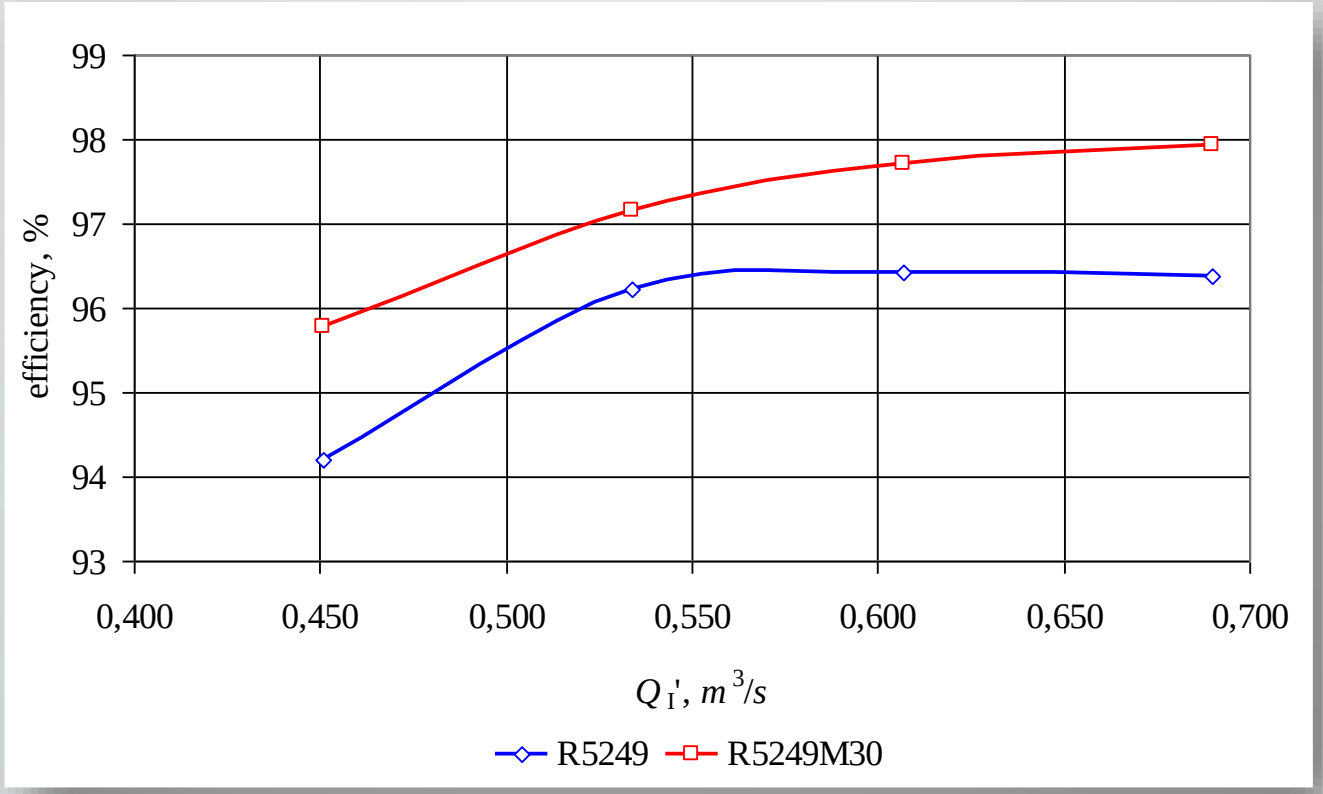


Pressure distribution in blade channel

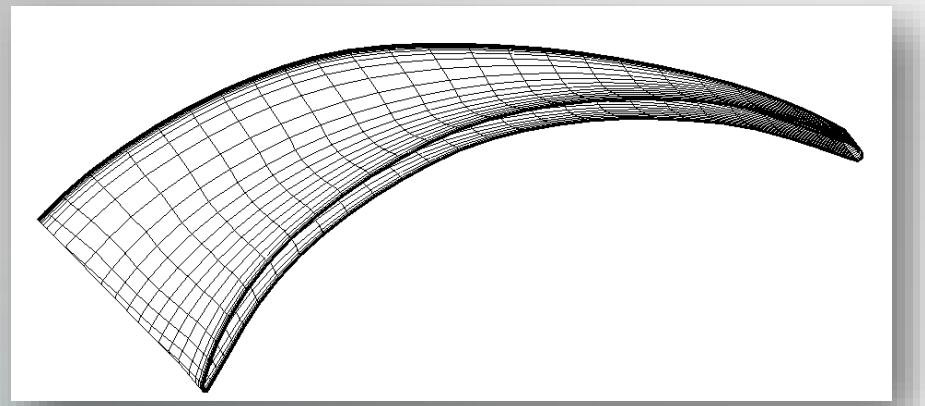
Runner of pump-turbine for heads of 80-120 m

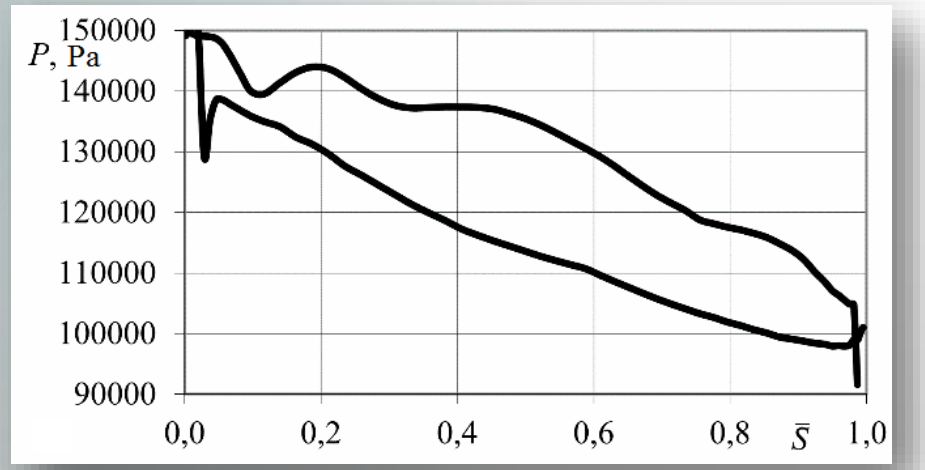
Efficiency in turbine mode, n_I' = 82 min^{-1}



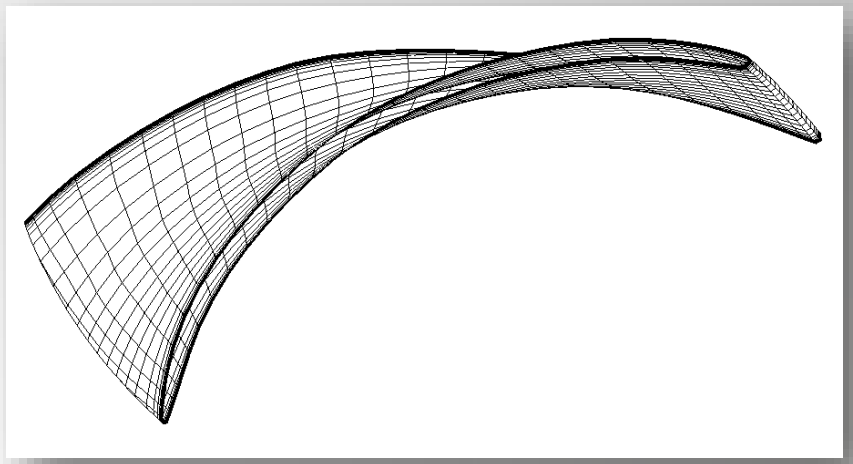
Runner of pump-turbine for heads of 170-200 m (Dniester PSP)

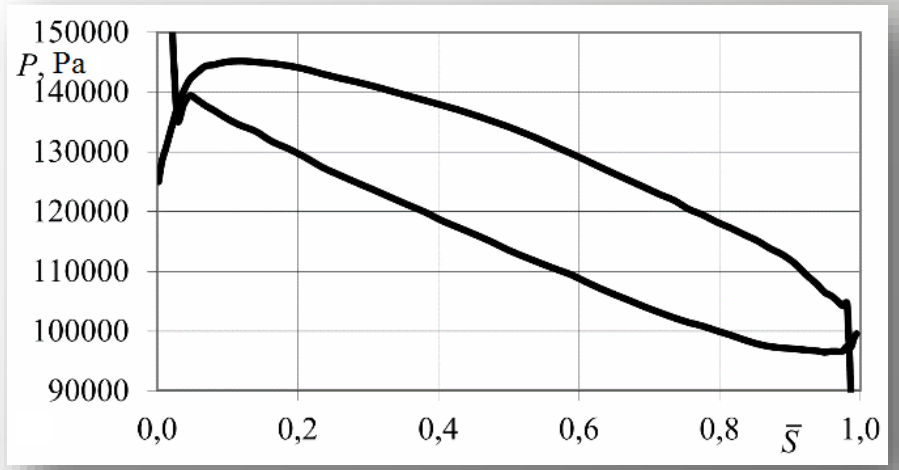
R5217





R5217M2

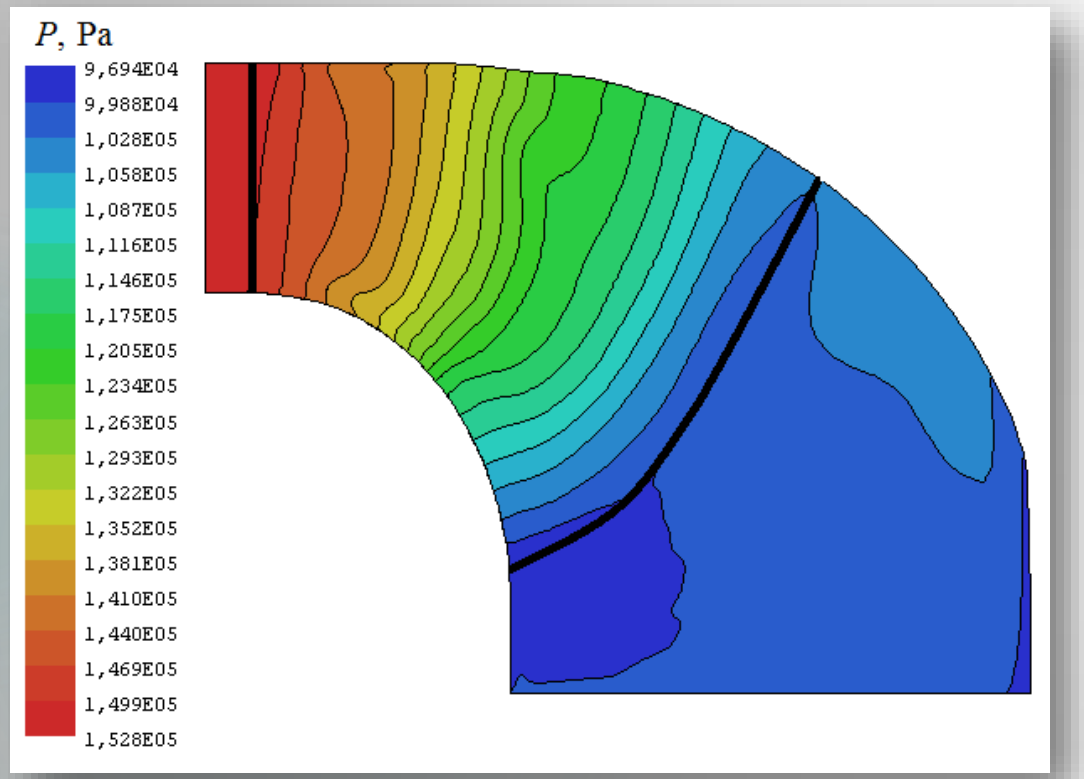




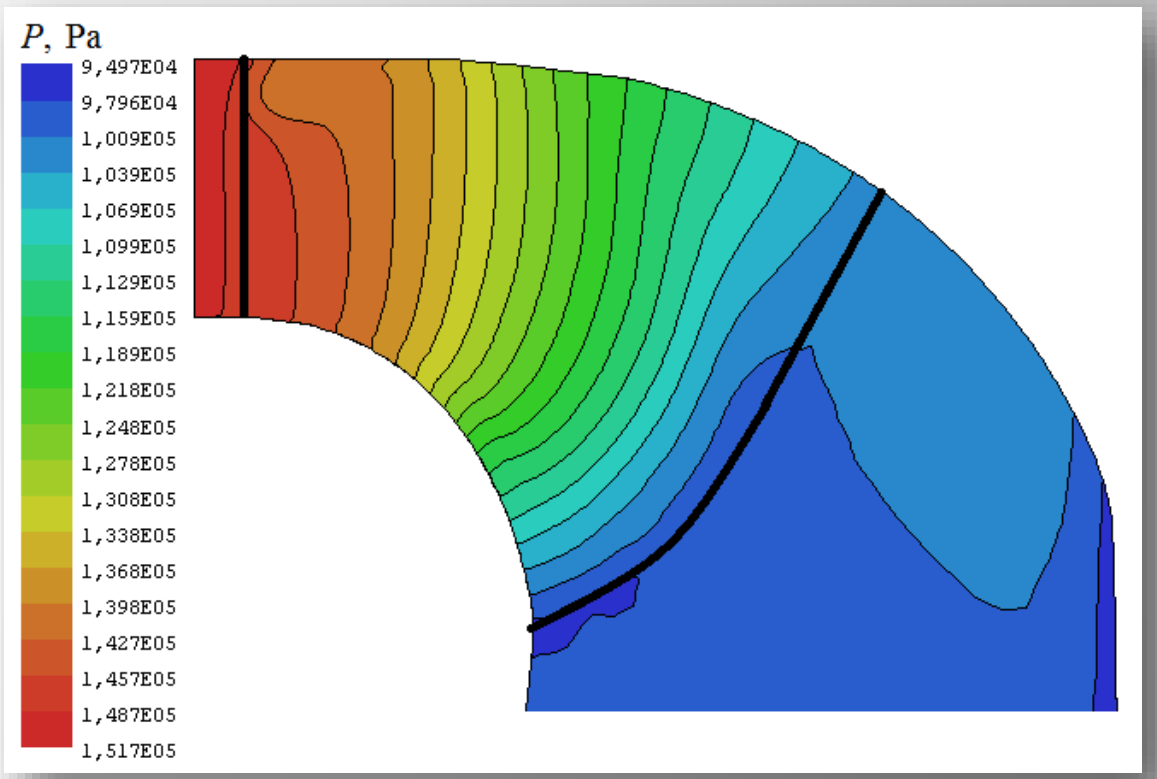
Pressure distribution in midspan

Runner of pump-turbine for heads of 170-200 m (Dniester PSP)

R5217



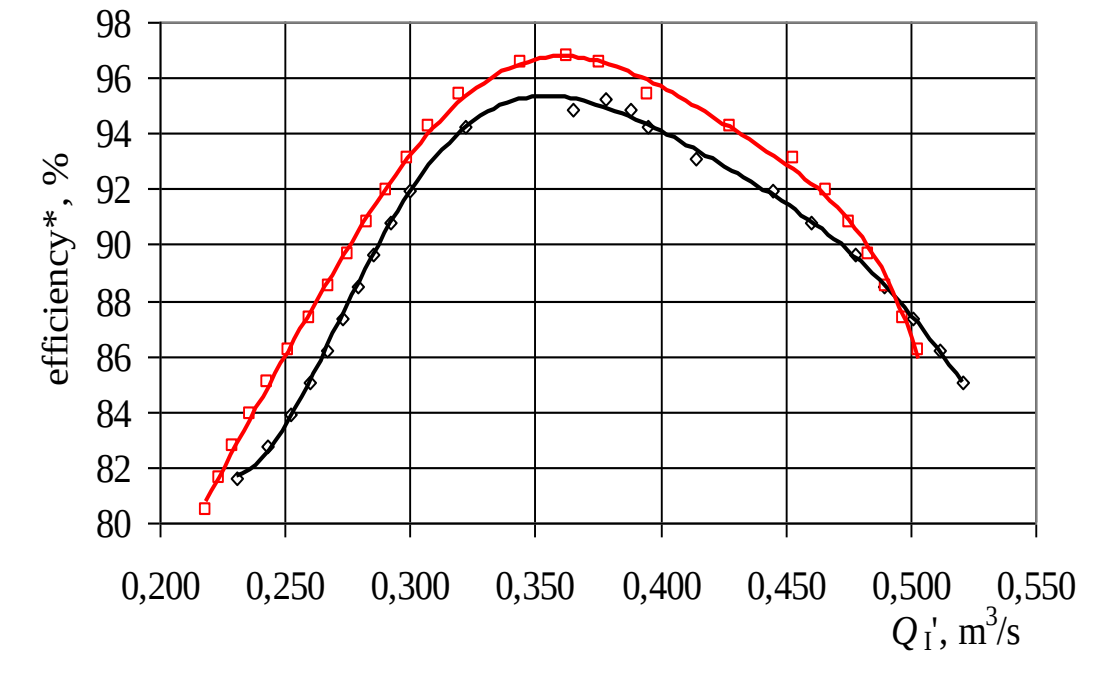
R5217M2



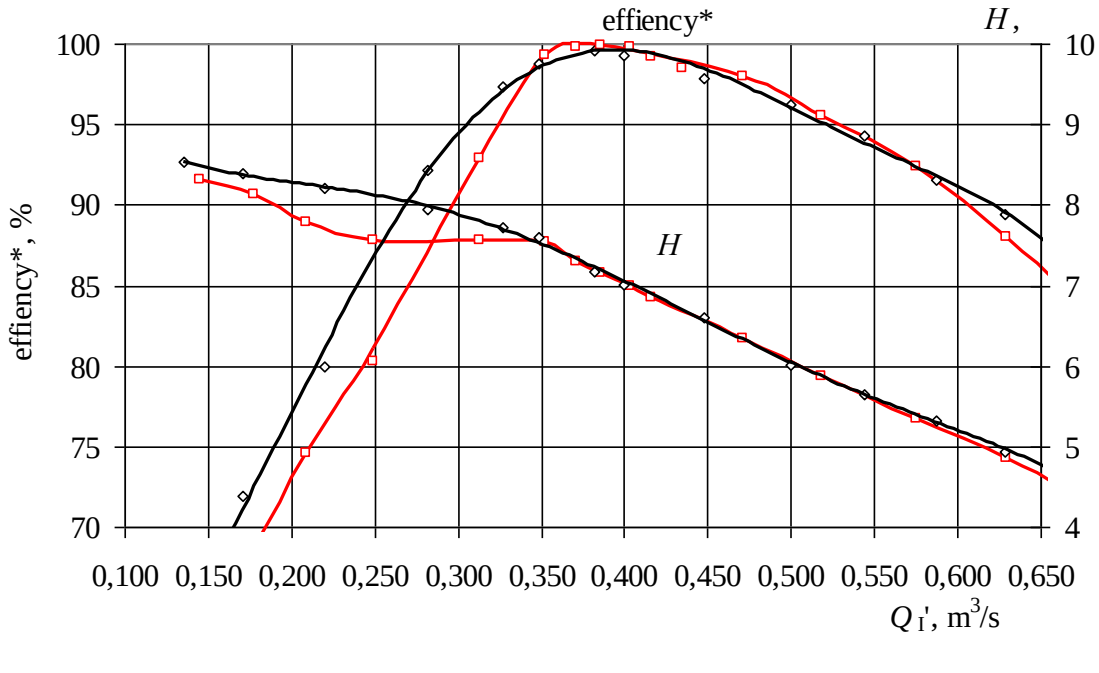
Pressure distribution in blade channel

Runner of pump-turbine for heads of 170-200 m (Dniester PSP)

Efficiency in turbine mode, n_I' = 95 min^{-1}



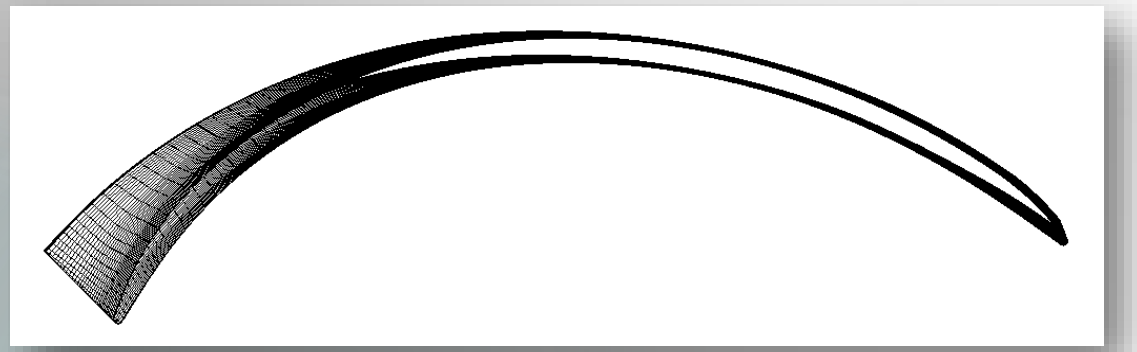
Efficiency in pump mode, a_0 = 30 mm



—◊— R5217; —□— R5217M2

Runner of pump-turbine for head of 500 m

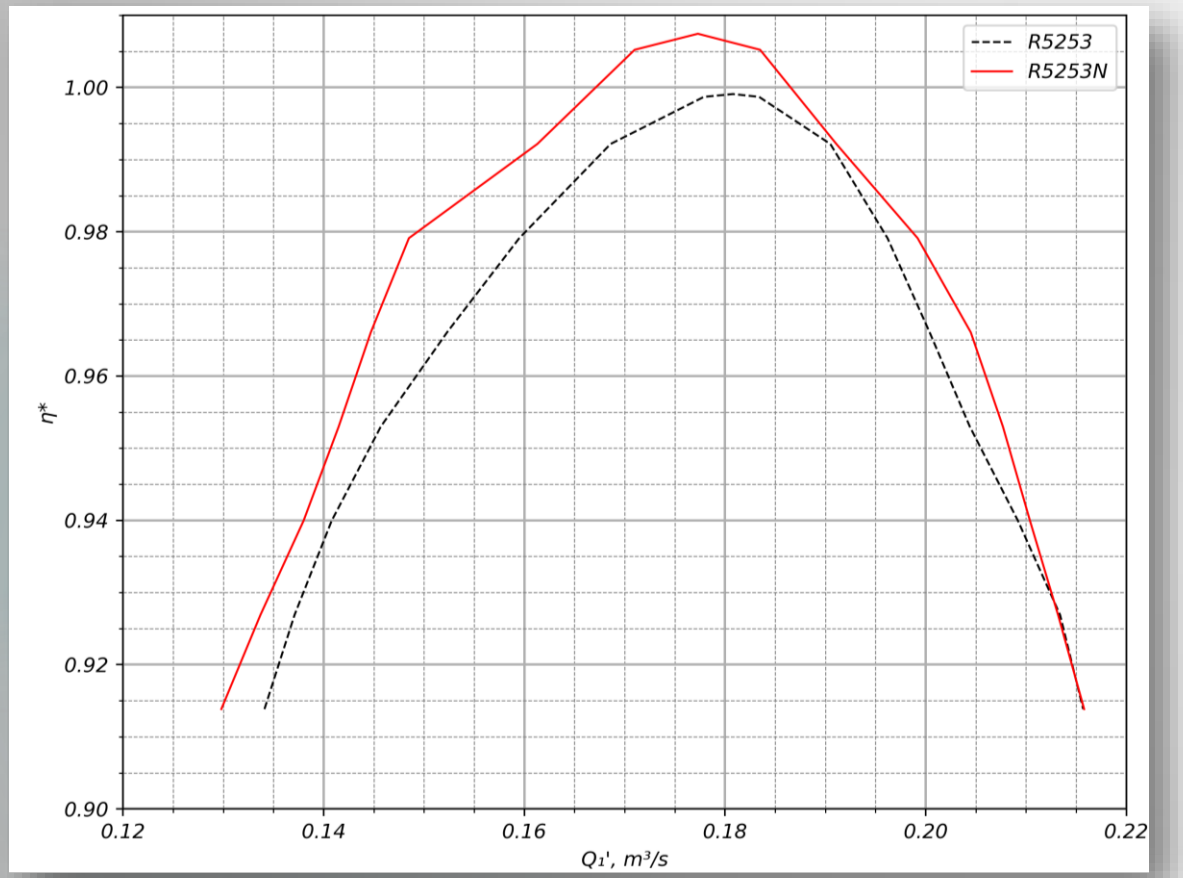
R5253



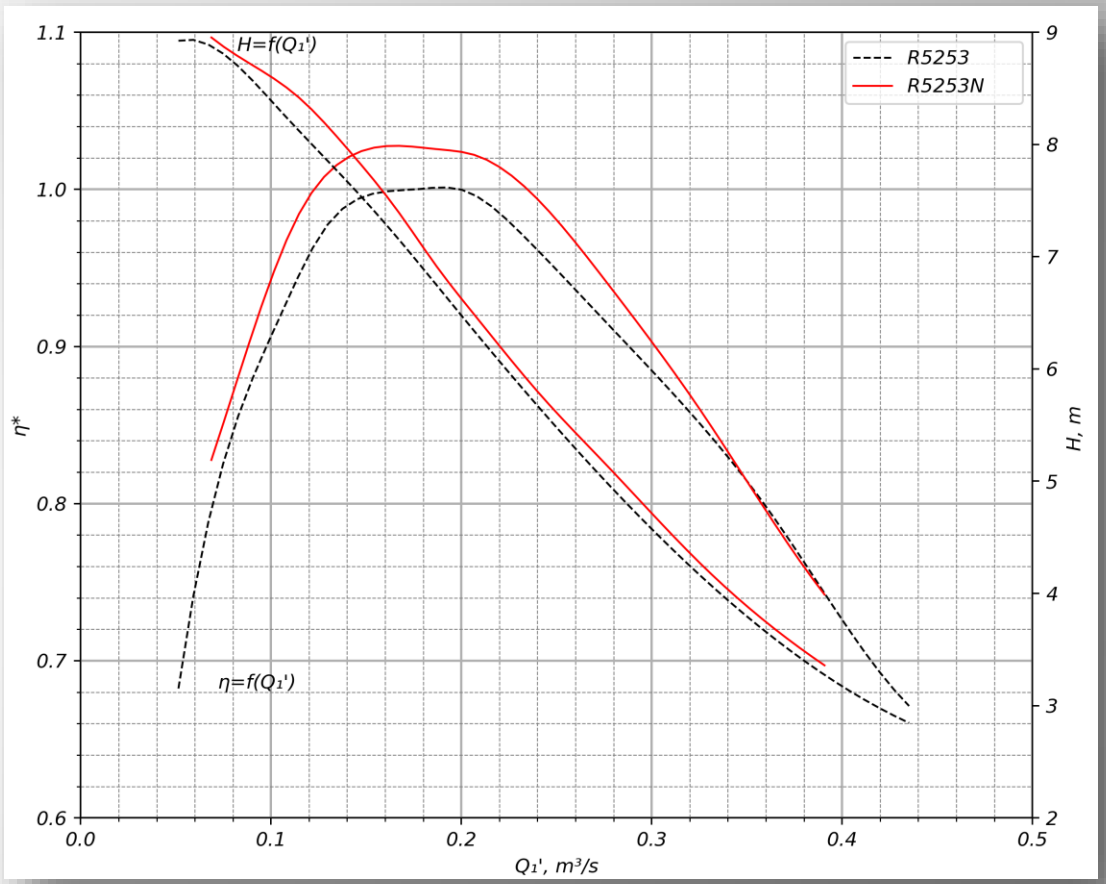
R5253N

Runner of pump-turbine for head of 500 m

Efficiency in turbine mode, n_1' = 80 min^{-1}

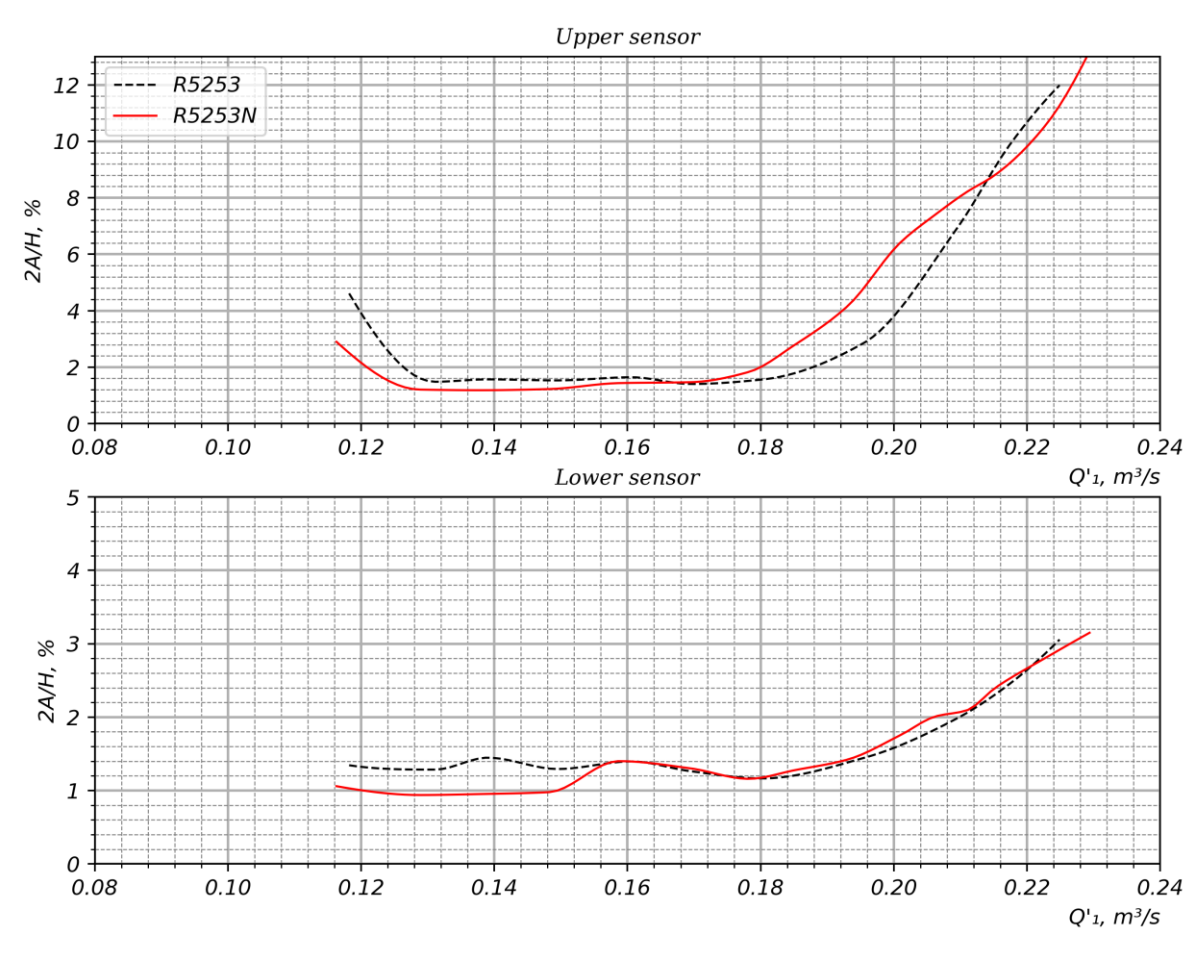


Efficiency in pump mode, a_0 = 24 mm

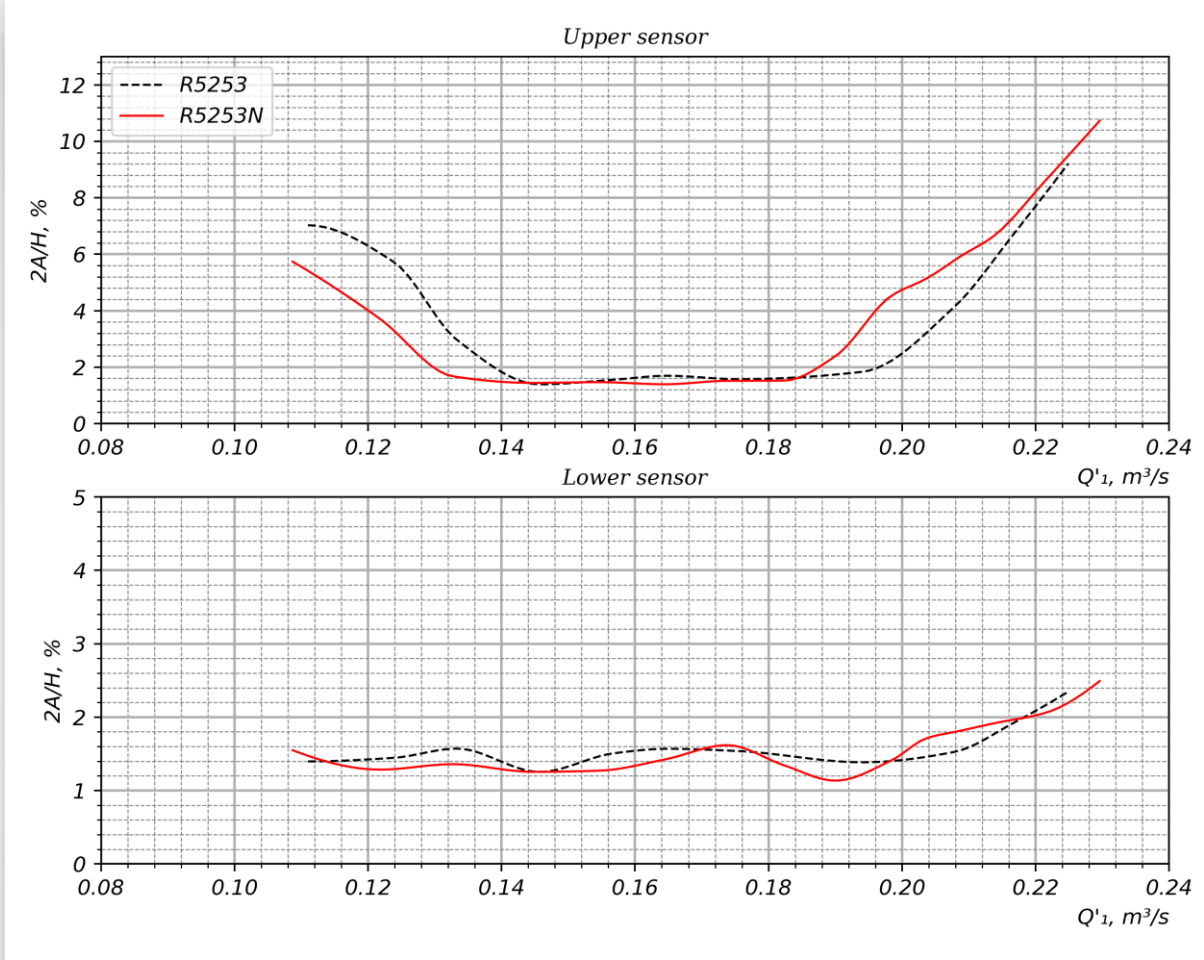


Runner of pump-turbine for head of 500 m

Pressure pulsations in draft tube



$n_1' = 80\ min^{-1}$



$n_1' = 85\ min^{-1}$

Conclusions

Based on the results of numerical and experimental studies of the influence of spatial profiling of pump-turbine runner blades on the characteristics of flow part models, the following new data were obtained:

- The use of circumferential leans can significantly affect the flow structure, which allows obtaining the most rational blade shape.
- The use of circumferential leans practically does not change the operating parameters of the best efficiency point on the hill chart in the turbine mode.
- Negative circumferential lean in the turbine mode leads to an increase in the efficiency of pump-turbine models in almost the entire range of head and guide vanes openings.
- The use of negative circumferential leans leads to an increase not only in the level of efficiency, but also in the head at almost all values of the guide vanes opening.
- Studies of the influence of circumferential leans on the level of pulsations in the suction pipe diffuser have shown that the use of negative heaps significantly reduces the level of pulsation amplitudes under partial load conditions, which allows to expand the range of safe operation of PSP hydraulic units.

THANK YOU FOR ATTENTION!