

Physics AI for Rapid, Physics-Based Pump Optimization

PROBLEM

Industrial pump design requires balancing performance, efficiency, and operating range, but traditional engineering workflows create a fundamental gap between early-stage assumptions and reality.

Engineers begin with low-fidelity 1D mean line tools that use simplified flow physics, which cannot capture complex 3D flow effects or viscous losses. Consequently, when designs reach high-fidelity CFD simulation for validation, actual performance often deviates significantly from initial 1D predictions, forcing costly design iterations and extending development timelines.



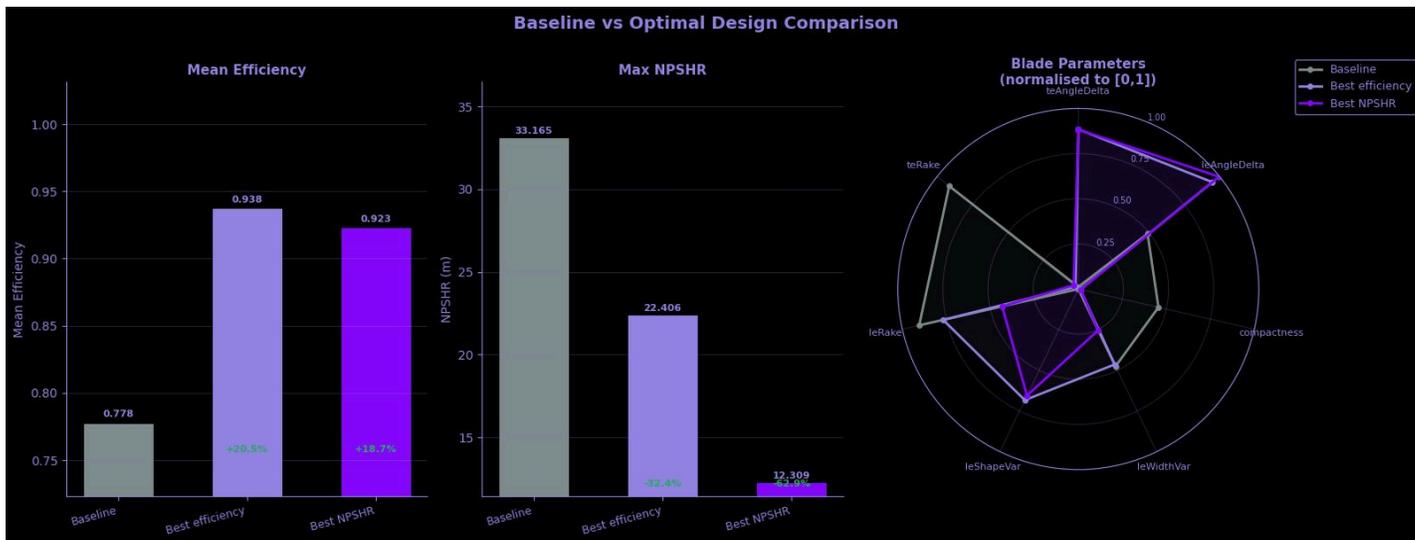
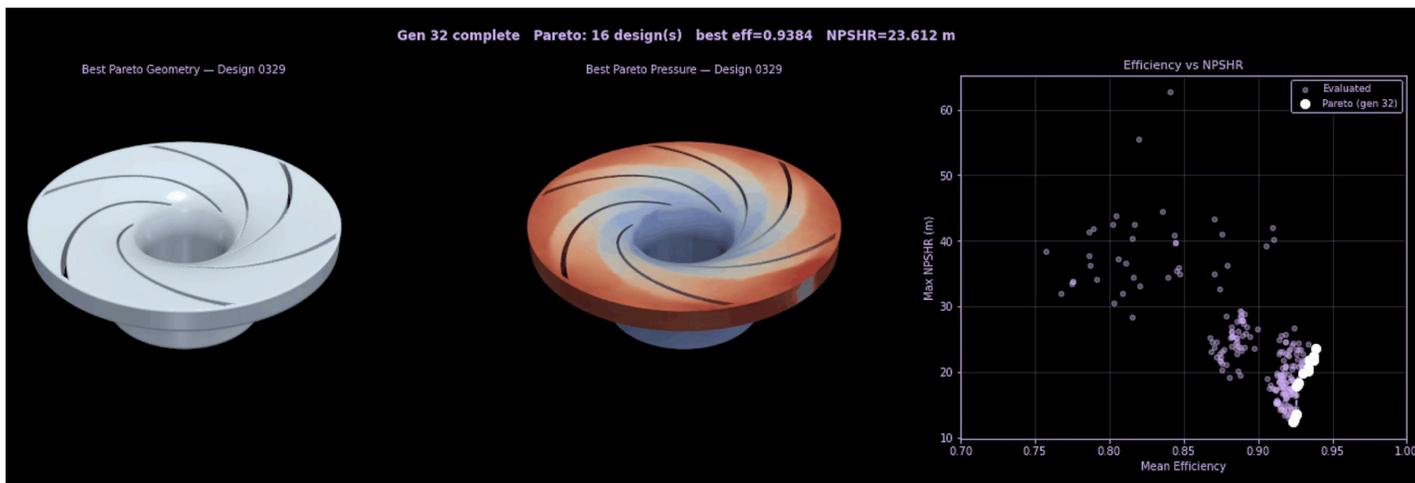
SOLUTION

Shrink days of simulation to seconds of AI prediction

SHIFT-Pump is a Physics AI model for industrial pump design, built using the NVIDIA DoMINO architecture and trained on over 5,500 high-fidelity RANS simulations. It provides near-instant performance predictions with CFD-level accuracy, bridging the gap between simplified 1D tools and expensive full-physics simulation. The model accepts flow rate as a direct input, which enables the rapid generation of complete efficiency curves across the full operating range (70 to 120 percent of design flow) in seconds. This speed transforms early-stage design: engineering teams can now explore thousands of design variants and conduct multi-objective optimization in minutes, enabling faster convergence on better-optimized products than previously possible with traditional CFD.

RESULTS

AI optimized design increases efficiency by 20% and decreases NPSHR by 63%



AI Model predicts pump performance with CFD-level accuracy

The SHIFT-Pump model learned the underlying physics governing pump performance, accurately predicting three key quantities of interest: actual head, torque, and efficiency. The model demonstrates strong correlation with CFD ground truth across the operating range, achieving an R^2 of 0.996 for torque prediction. Crucially, it accurately captures the nonlinear relationship between flow rate and pressure rise, including complex effects at off-design conditions. This capability allows it to successfully predict complete efficiency curves across flow rates from 70 to 120 percent of design conditions, matching high-fidelity CFD results.

“Physics AI is the next level of complexity in AI, and Northrop Grumman is bringing this technology to our design engineers to dramatically speed up hardware development.”



Han Park
Vice President, Artificial Intelligence Integration



LEARN MORE

Try the pump prediction demo:

<https://www.luminarycloud.com/demo/>