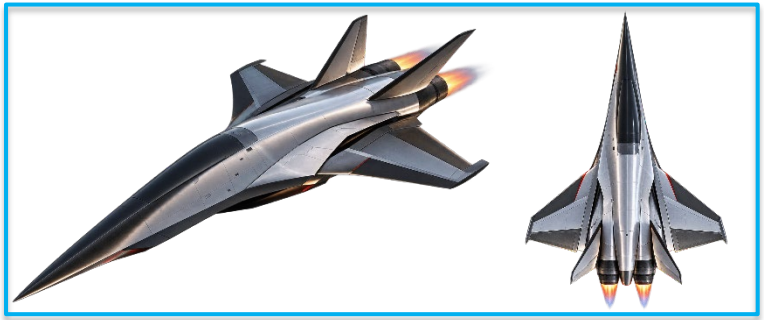
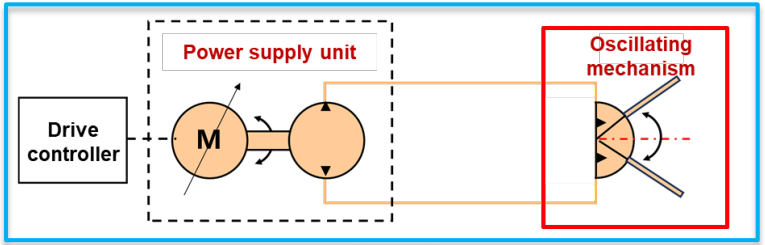
INTRODUCTION

Morphing hypersonic vehicle

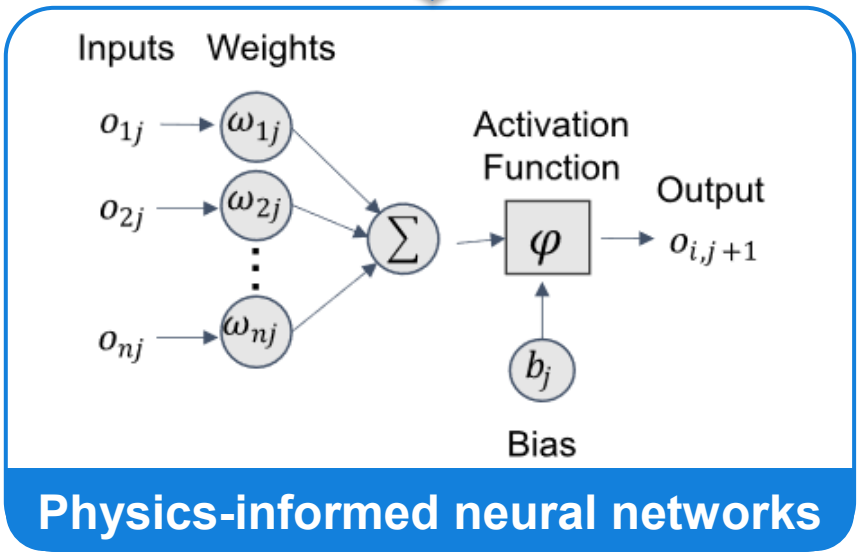


Wing actuation system



Starting Pressure

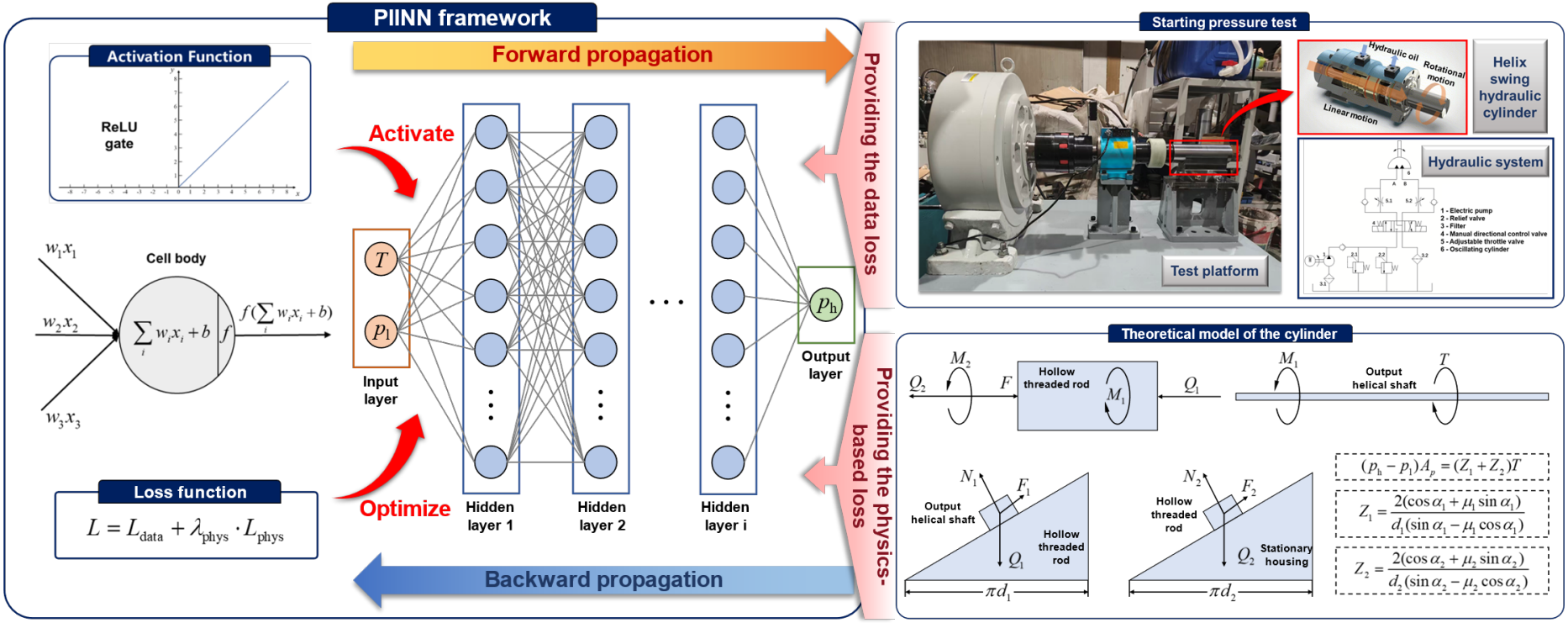
- **Conventional analytical model**: Too idealistic
- **Experimental approach** : Not comprehensive



Physics-informed neural networks

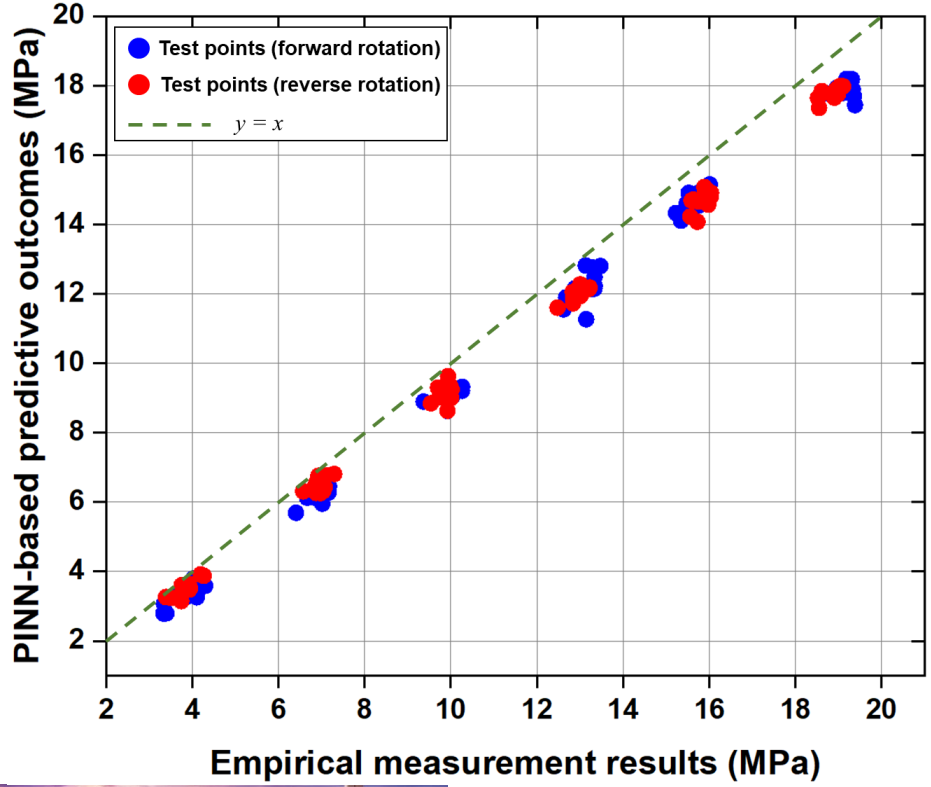
➢ Mechanism–data fusion framework

☐ Construction of a mechanism-data fusion architecture based on PINN



RESULTS

☐ Predictive Analysis of Forward and Reverse Starting Pressures



The PINN prediction outcomes and the experimental datasets are co-plotted and superimposed:

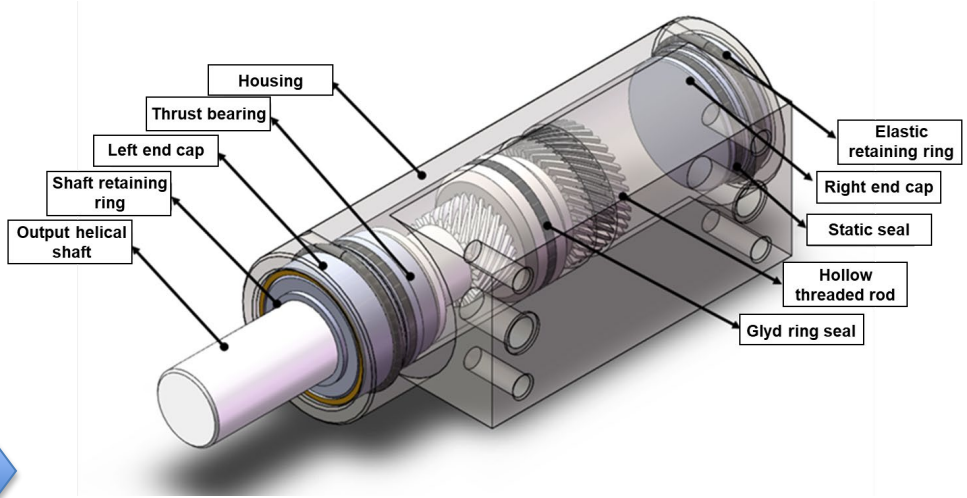
- The PINN model yields higher predictive fidelity and closer alignment.
- The scatter points for the reverse operation exhibit a closer proximity to the $y=x$ line.
- For every 50 Nm increment in the external load torque, the starting pressure must increase by roughly 3 MPa.

IMPACT

Near-space flight mission



- High torque
- Compact envelope
- Wide angular range
- Robust impact resistance



This approach provides a highly reliable parameter prediction method for the development and optimization of actuation systems in modern morphing aircraft.



OUTLOOK

Theoretical equation

① $F = Q_1 + Q_2$ ② $M_1 = M_2 = T$ ③ $Q_1 = N_1(\cos\alpha_1 + \mu_1 \sin\alpha_1)$

④ $Q_2 = N_2(\cos\alpha_2 + \mu_2 \sin\alpha_2)$ ⑤ $M_1 = N_1(\sin\alpha_1 - \mu_1 \cos\alpha_1)\cdot\frac{1}{2}d_1$

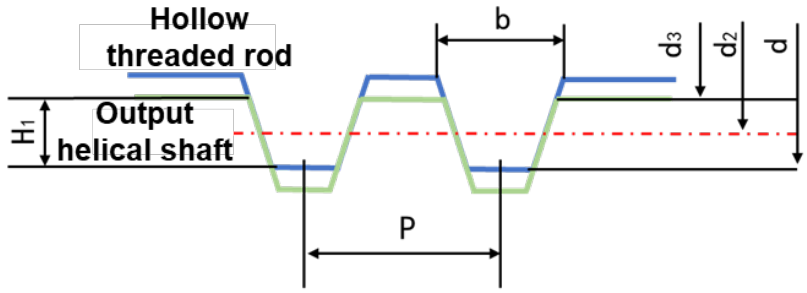
⑥ $M_2 = N_2(\sin\alpha_2 - \mu_2 \cos\alpha_2)\cdot\frac{1}{2}d_2$ ⑦ $F = (p_h - p_l)A_p$

combine

$$(p_h - p_1)A_p = (Z_1 + Z_2)T$$

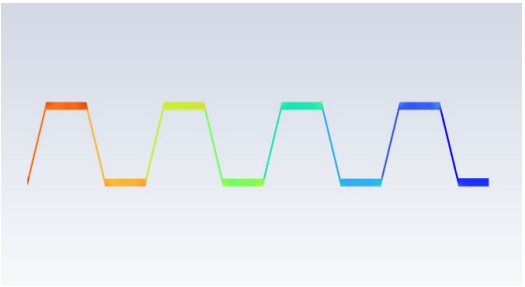
$$Z_1 = \frac{2(\cos\alpha_1 + \mu_1 \sin\alpha_1)}{d_1(\sin\alpha_1 - \mu_1 \cos\alpha_1)} \qquad Z_2 = \frac{2(\cos\alpha_2 + \mu_2 \sin\alpha_2)}{d_2(\sin\alpha_2 - \mu_2 \cos\alpha_2)}$$

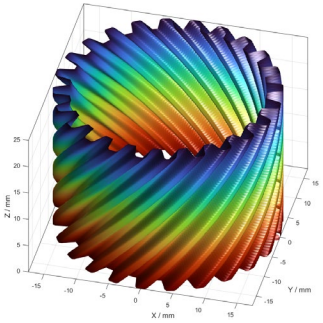
The construction of the theoretical model is rather idealized.



30° Trapezoidal Thread

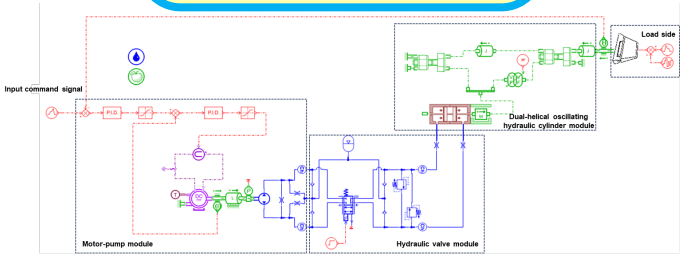
Pressure drop of the thread?





TAKEAWAY

Physical Mechanism



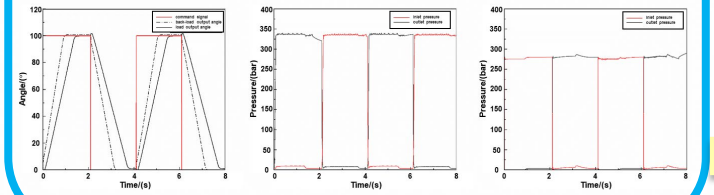
$$\frac{\partial \rho}{\partial t}+\frac{\partial(\rho u)}{\partial x}+\frac{\partial(\rho v)}{\partial y}+\frac{\partial(\rho w)}{\partial z}=\frac{\partial \rho}{\partial t}+\nabla\cdot(\rho\vec{v})=0$$

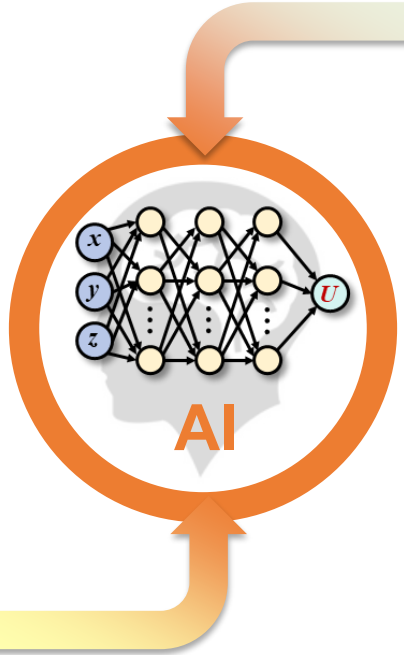
$$\frac{\partial(\rho u)}{\partial t}+\nabla\cdot\vec{v}=-\frac{\partial p}{\partial x}+\frac{\partial \tau_{xx}}{\partial x}+\frac{\partial \tau_{yx}}{\partial y}+\frac{\partial \tau_{zx}}{\partial z}+F_x$$

$$\frac{\partial(\rho T)}{\partial t}+\frac{\partial(\rho u T)}{\partial x}+\frac{\partial(\rho v T)}{\partial y}+\frac{\partial(\rho w T)}{\partial z}=\frac{\partial}{\partial x}\left(\frac{k_t}{c_p}\frac{\partial T}{\partial x}\right)+\frac{\partial}{\partial y}\left(\frac{k_t}{c_p}\frac{\partial T}{\partial y}\right)+\frac{\partial}{\partial z}\left(\frac{k_t}{c_p}\frac{\partial T}{\partial z}\right)+S_T$$

$$M=\frac{35\cdot\pi\cdot 50^2\cdot 32\cdot 44}{8\cdot\left[\frac{44}{\tan(50-4.6)}+\frac{32}{\tan(50-4.6)}\right]}\approx 645N\cdot\mathrm{m}$$

$$\gamma=\gamma_1+\gamma_2=100°$$





Test Data

