



## Thrusters

# Dynamics of Propeller Blade and Duct Loading on Ventilated Thrusters in Dynamic Positioning Mode

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**MARINEK**

*(Presentation is not yet available)*

*October 9-10, 2007*

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DYNAMIC  
POSITIONING  
CONFERENCE 2007



# Dynamics of Propeller Blade and Duct Loadings on Ventilated Thrusters in Dynamic Positioning Mode

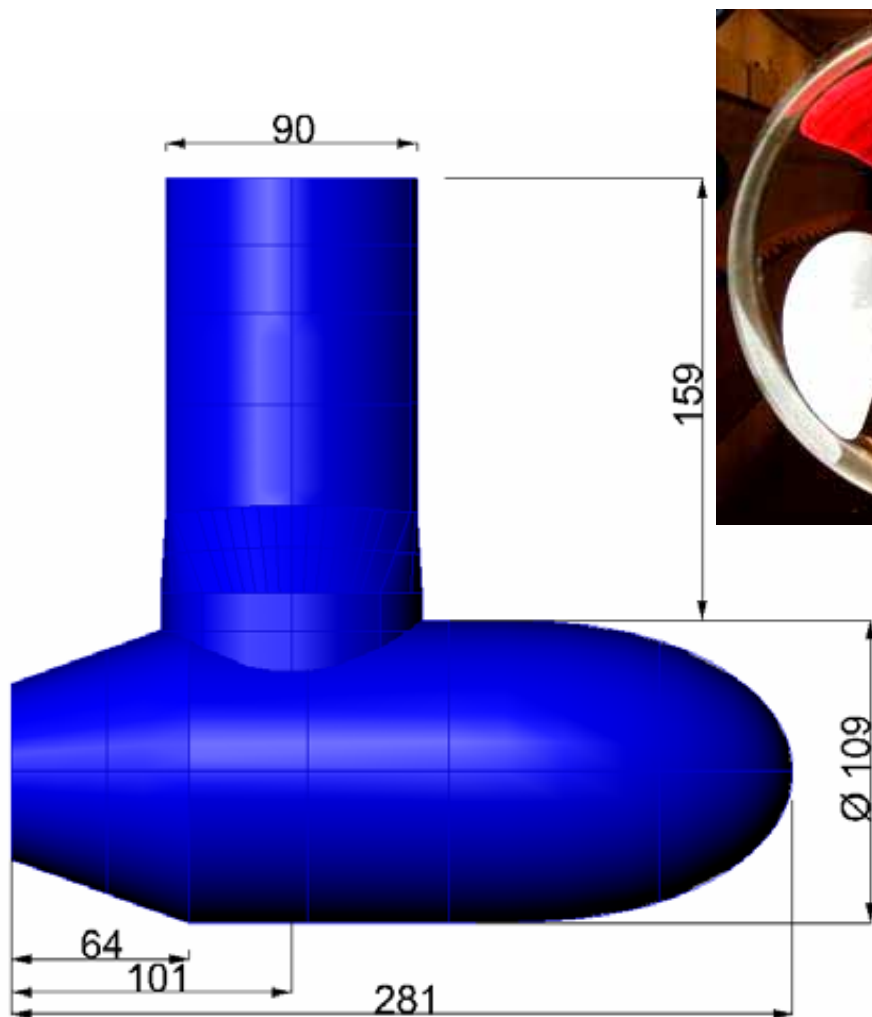
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MARINTEK

Norwegian Marine Technology Research Institute

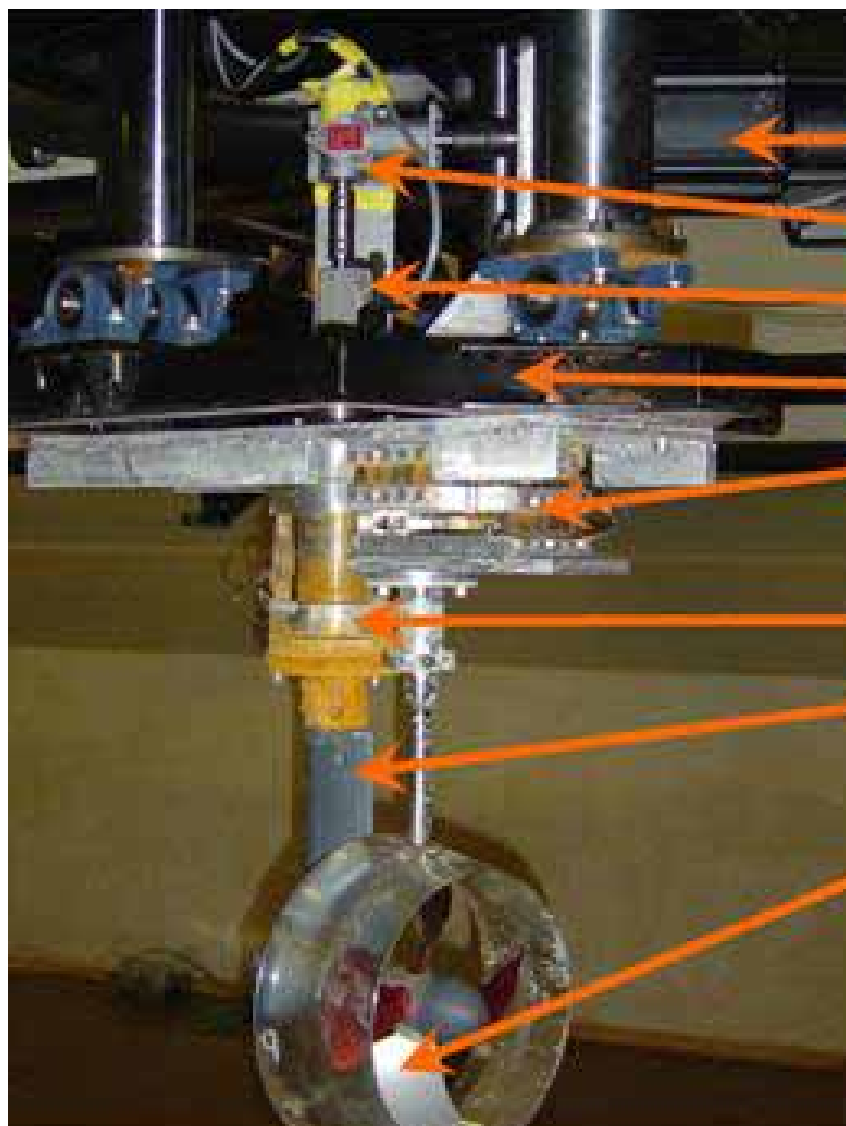
# Propeller and thruster models



## Open thruster

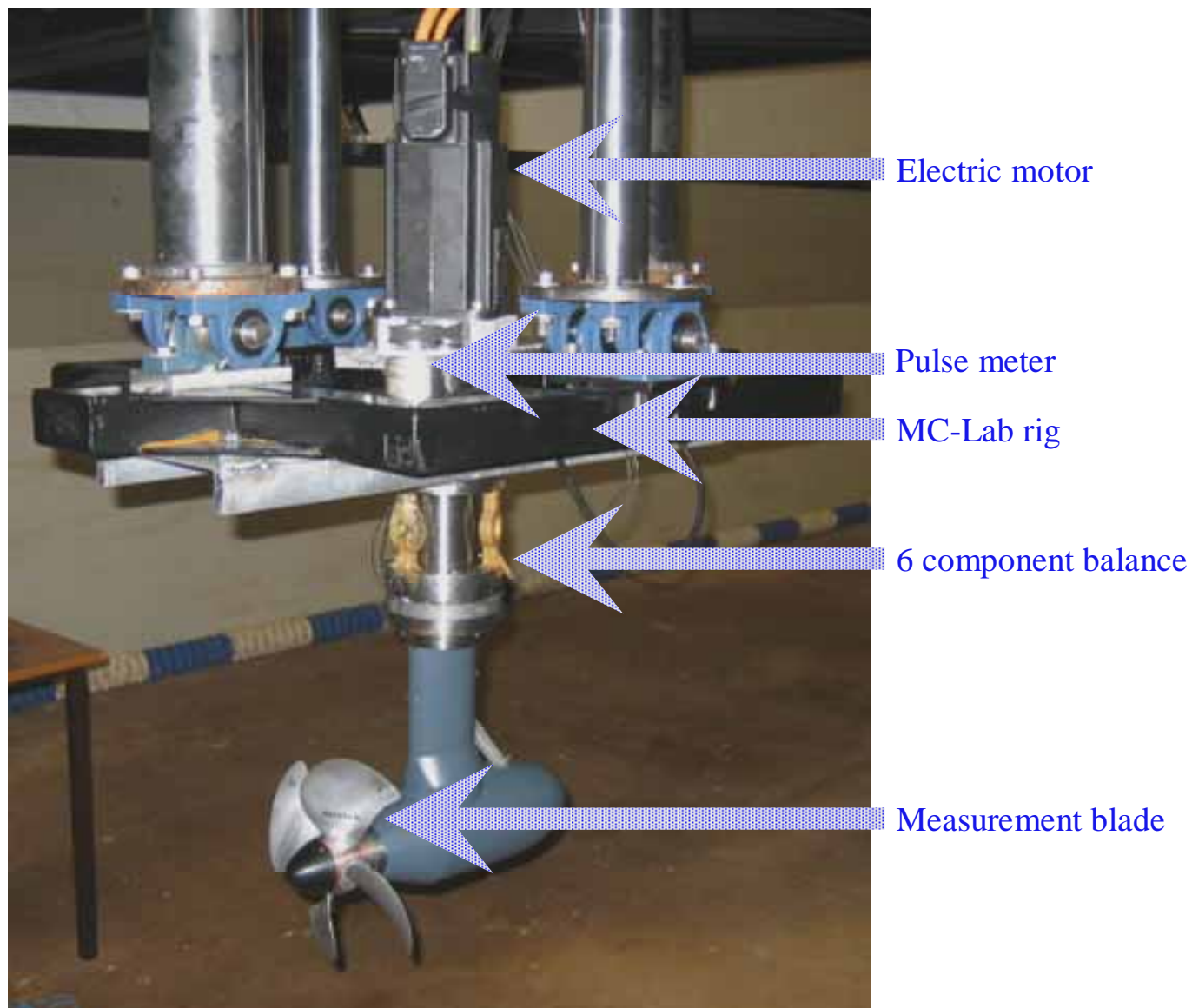
## Ducted thruster

## Test set-up for ducted thruster tests



- Electric motor
- Gear
- Torque-meter
- MClab-rig
- X & Y force transducer for duct
- Six component balance
- Thruster body including wireless transmission
- Blade attached to six component blade dynamometer

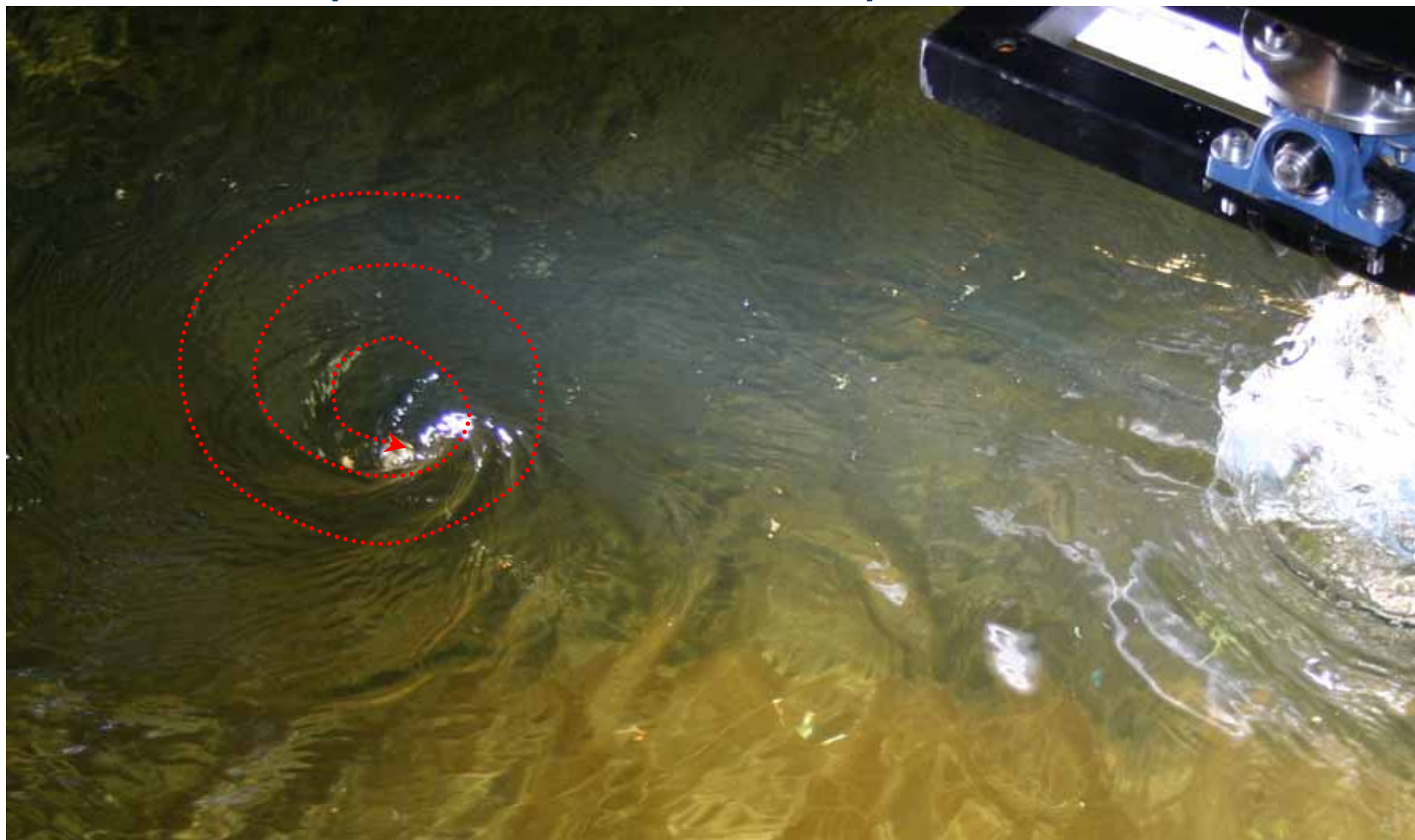
# Test set-up for open thruster tests



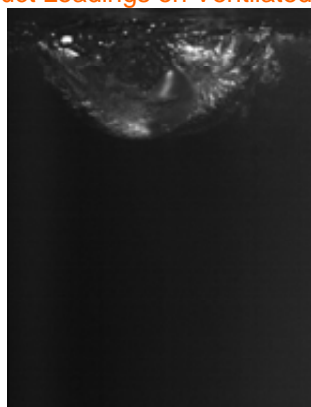
# Tested parameters

- All tests
  - Different propeller rate of revolutions
  - Speed (negative, zero and positive)
- Constant immersion tests
  - Different immersion ratios
  - Different azimuth angles
- Dynamic azimuthing tests
  - Different immersion ratios
- Dynamic vertical motion tests
  - Different starting immersion ratios
  - Different amplitudes
  - Different periods

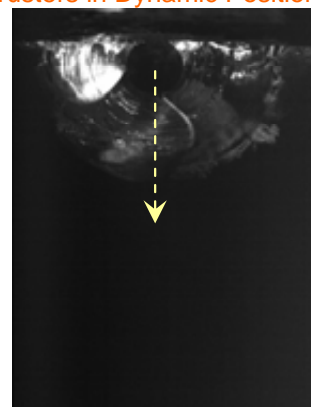
# Open thruster; funnel centre on water surface $h/R = 2.6$ (constant immersion)



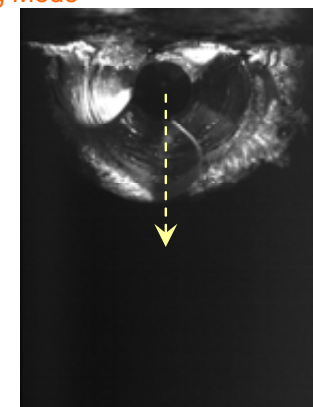
Open thruster;  
 shaft immersion  
 ratio at highest  
 position  
 $h/R = -0.15$ ,  
 amplitude/R=2.15,  
 period=2s



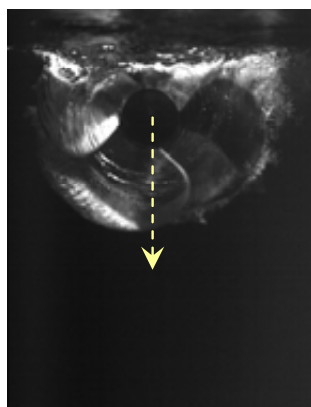
(a)  $h/R = -0.15 + 0$  amplitude/R = -0.15



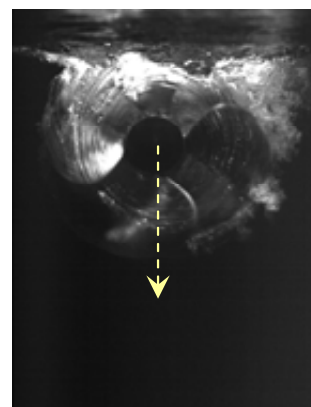
(b)  $h/R = -0.15 + 0.14$  amplitude/R = 0.15



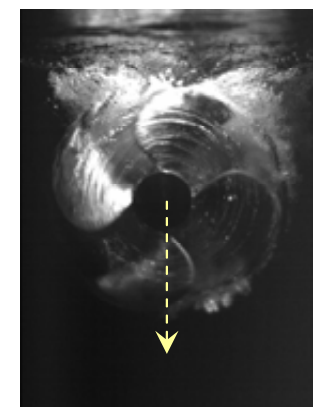
(c)  $h/R = -0.15 + 0.22$  amplitude/R = 0.31



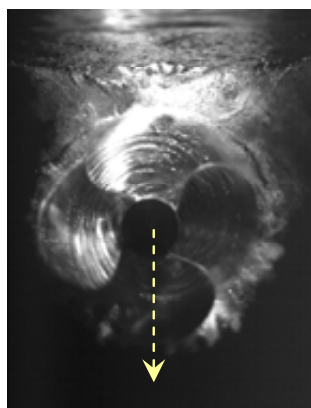
(d)  $h/R = -0.15 + 0.33$  amplitude/R = 0.56



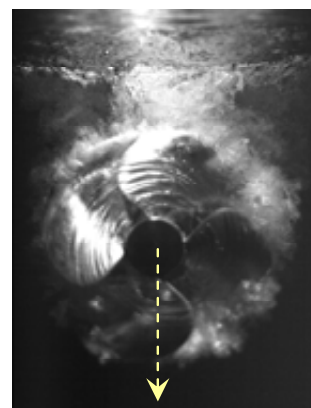
(e)  $h/R = -0.15 + 0.44$  amplitude/R = 0.79



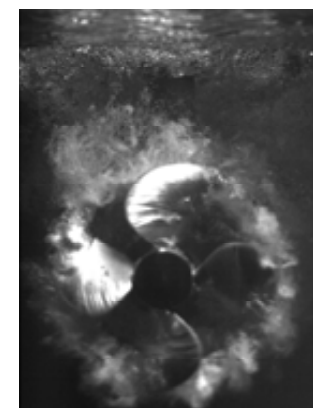
(f)  $h/R = -0.15 + 0.66$  amplitude/R = 1.28



(g)  $h/R = -0.15 + 0.76$  amplitude/R = 1.48



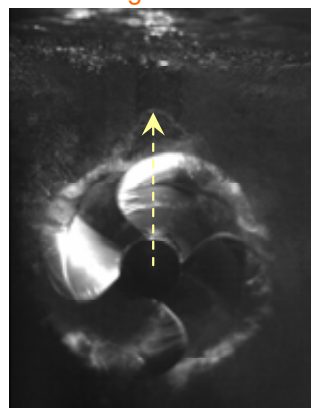
(h)  $h/R = -0.15 + 0.84$  amplitude/R = 1.66



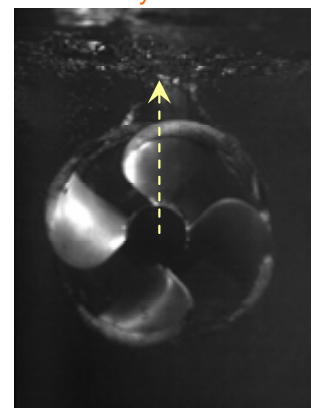
(i)  $h/R = -0.15 + 1$  amplitude/R = 2

Continued...

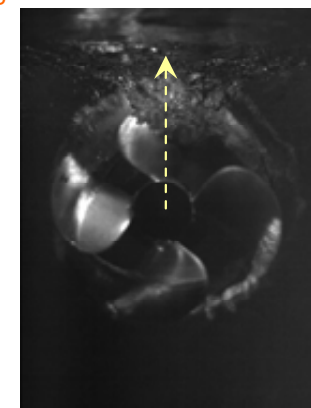
Open thruster;  
shaft immersion  
ratio at highest  
position  
 $h/R = -0.15$ ,  
amplitude/ $R = 2.15$ ,  
period = 2s



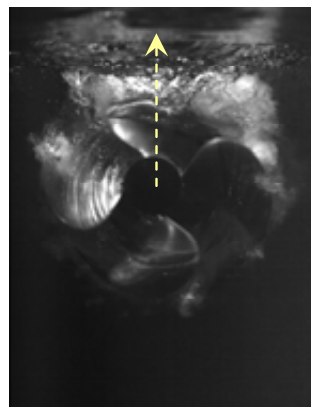
(j)  $h/R = -0.15 + 0.97$  amplitude/ $R = 1.95$



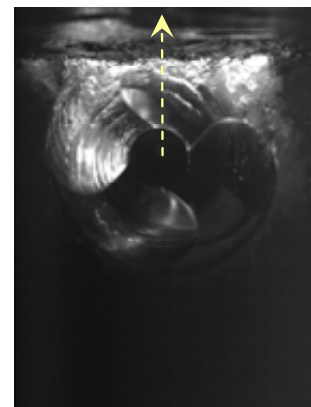
(k)  $h/R = -0.15 + 0.86$  amplitude/ $R = 1.7$



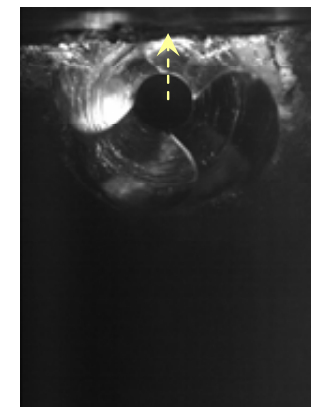
(l)  $h/R = -0.15 + 0.77$  amplitude/ $R = 1.5$



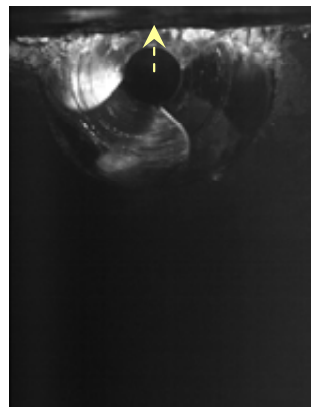
(m)  $h/R = -0.15 + 0.66$  amplitude/ $R = 1.26$



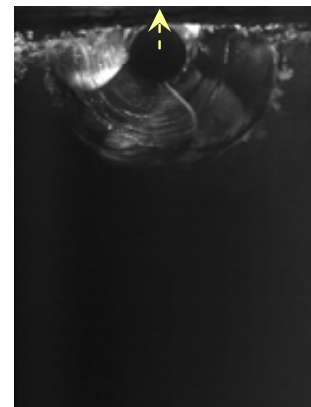
(n)  $h/R = -0.15 + 0.56$  amplitude/ $R = 1.07$



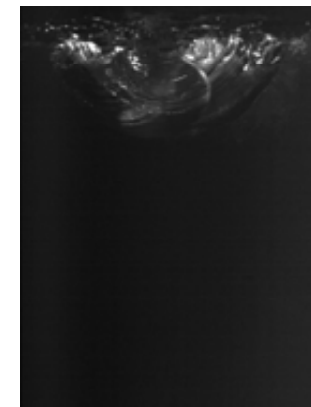
(o)  $h/R = -0.15 + 0.34$  amplitude/ $R = 0.58$



(p)  $h/R = -0.15 + 0.24$  amplitude/ $R = 0.37$

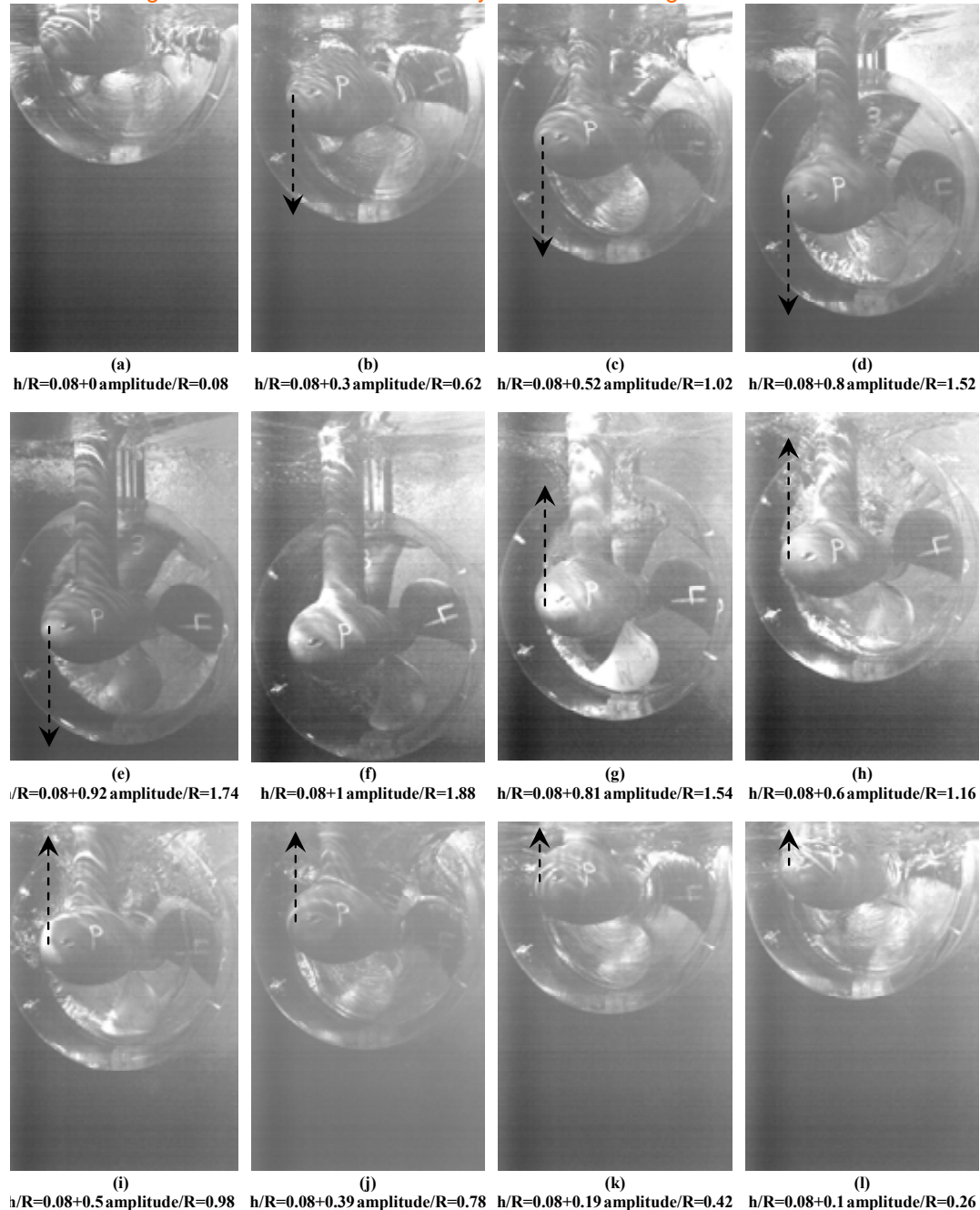


(q)  $h/R = -0.15 + 0.14$  amplitude/ $R = 0.15$

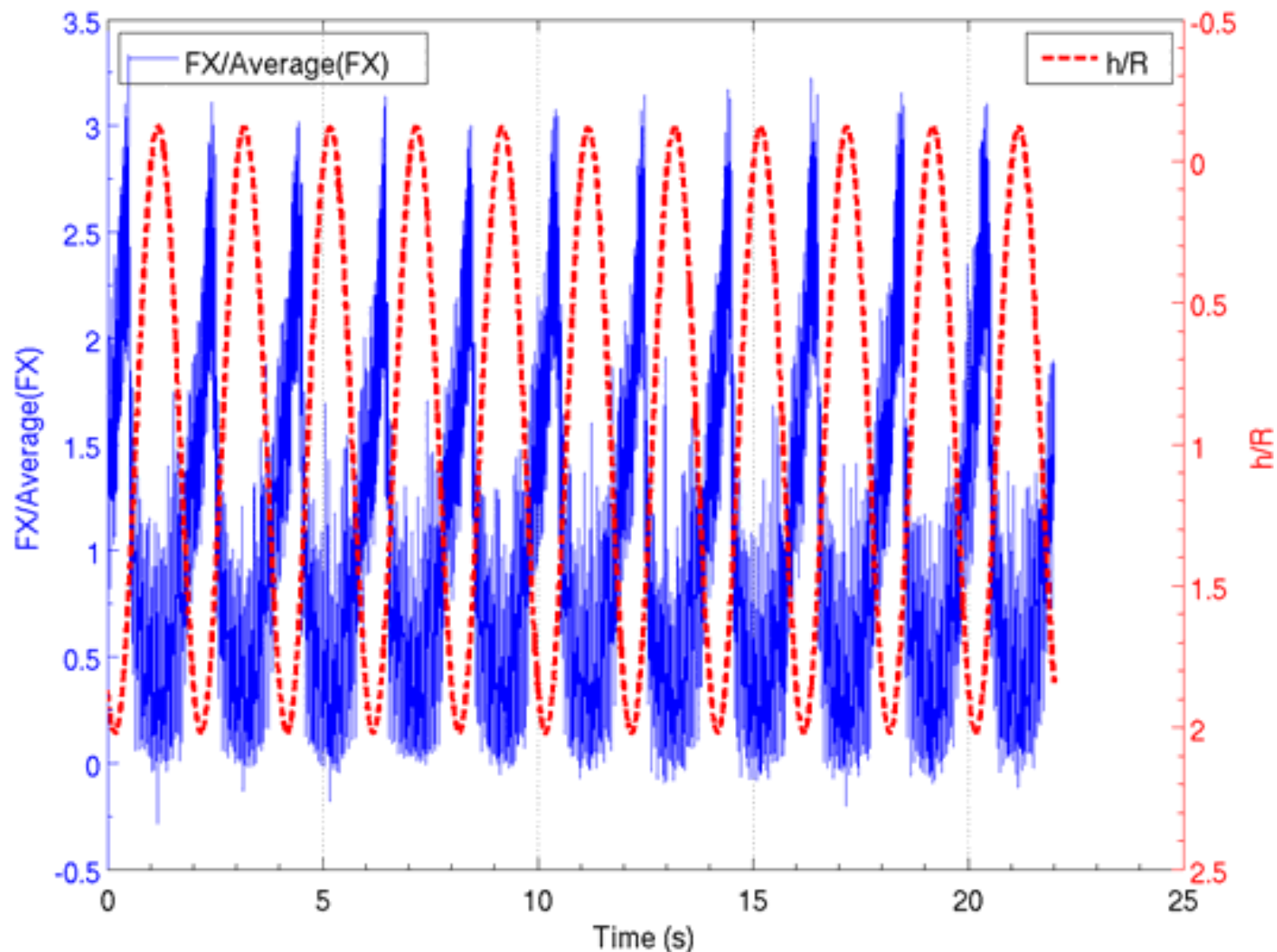


(r)  $h/R = -0.15 + 0$  amplitude/ $R = -0.15$

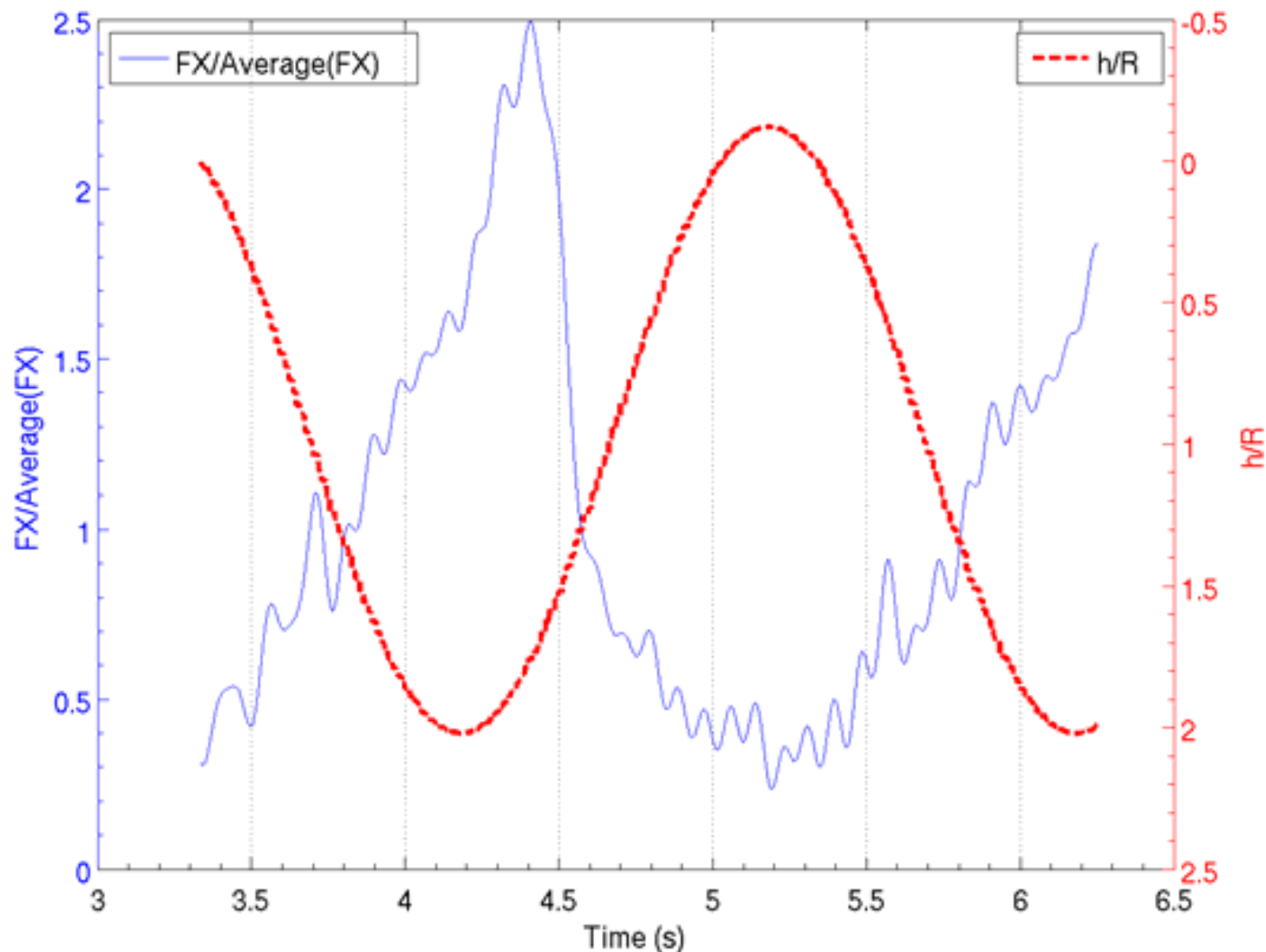
**Ducted thruster;  
shaft immersion  
ratio at highest  
position  
 $h/R = -0.08$ ,  
amplitude/ $R = 1.8$ ,  
period = 4s**



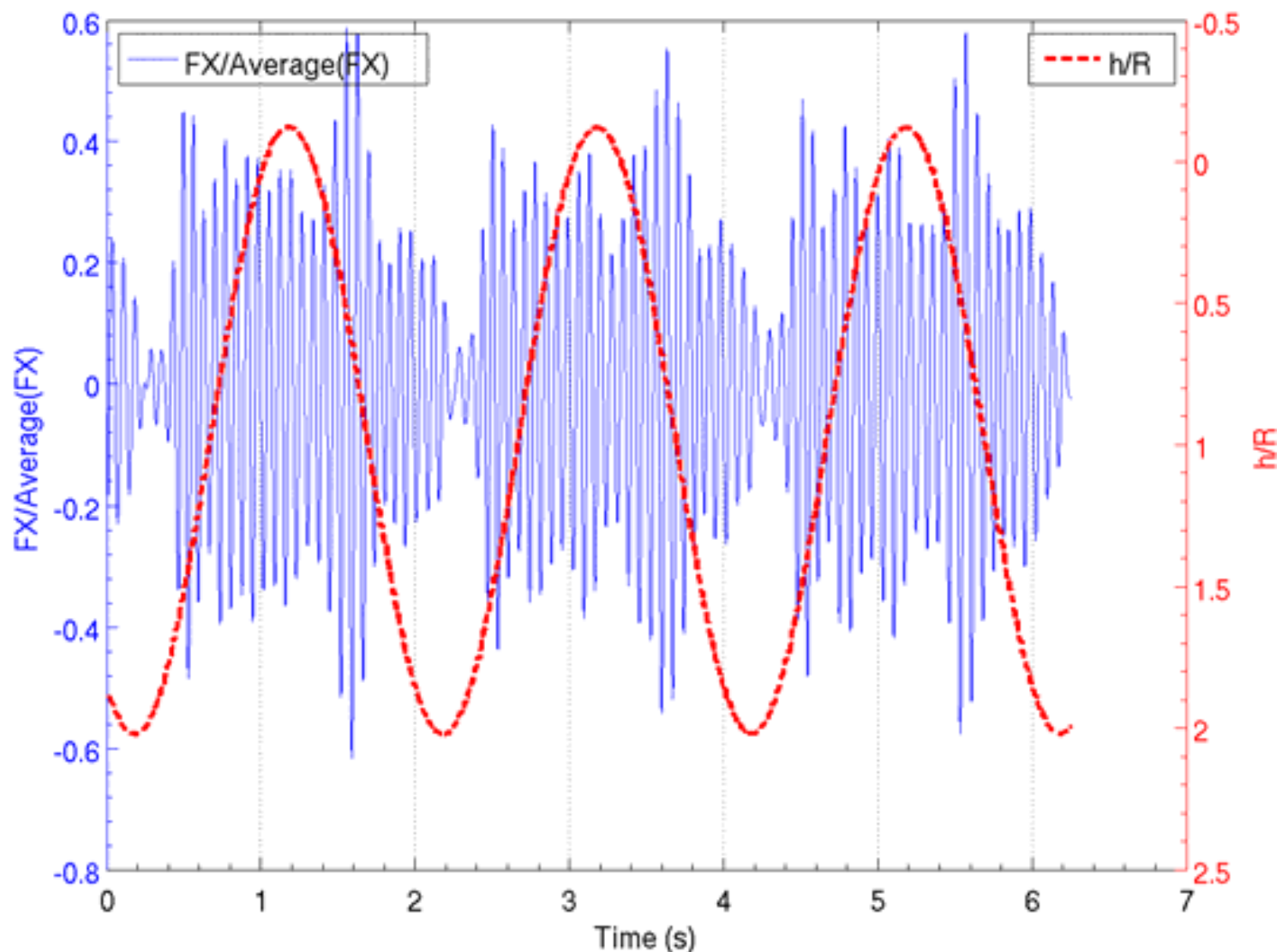
# Open thruster; Relative blade thrust min. $h/R = -0.15$ ; amplitude $/R = 2.15$ ; $T = 2$ s



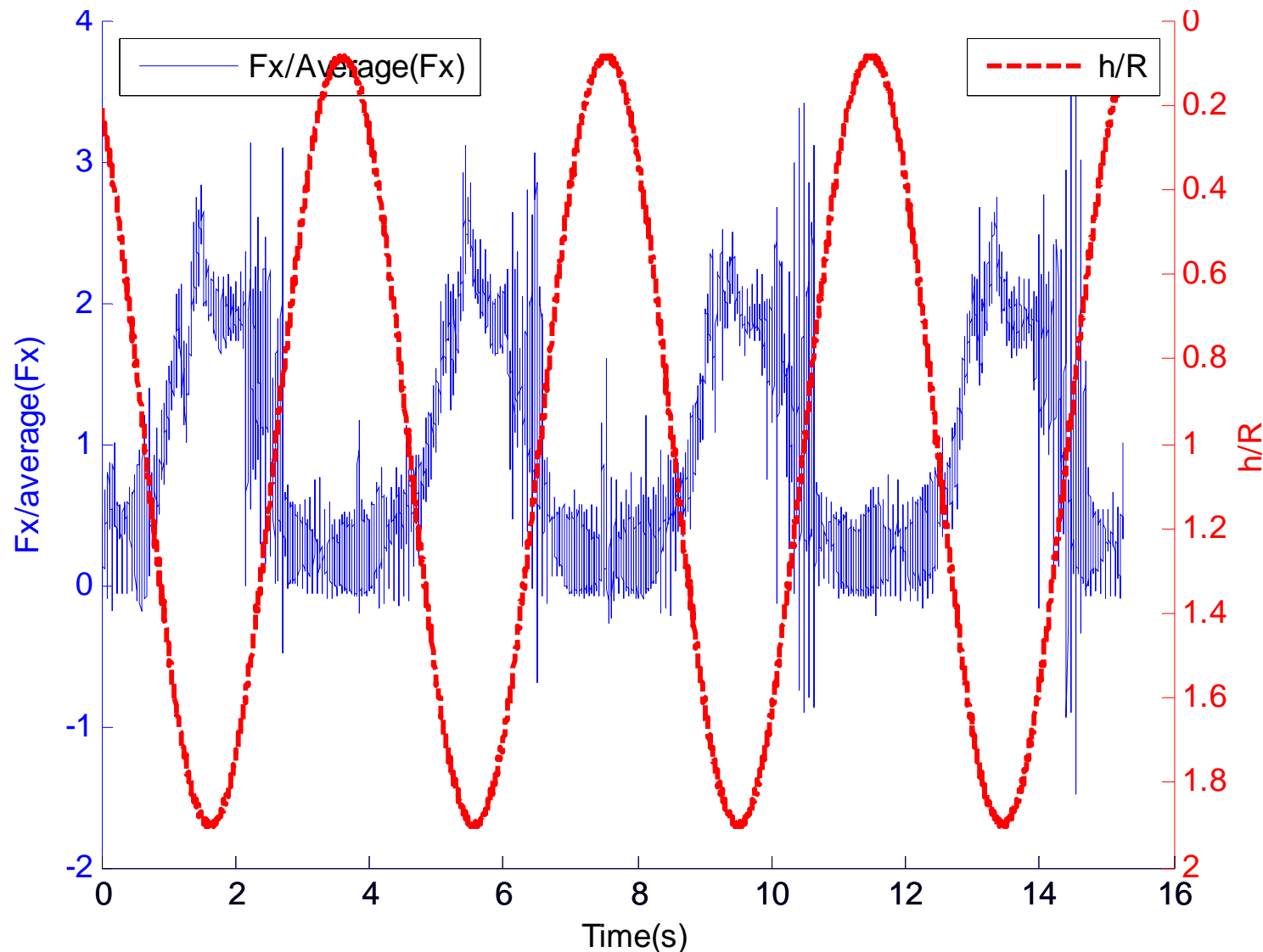
# Open thruster; Low pass filtered blade thrust; min. $h/R = -0.15$ ; amplitude/ $R = 2.15$ ; $T = 2$ s



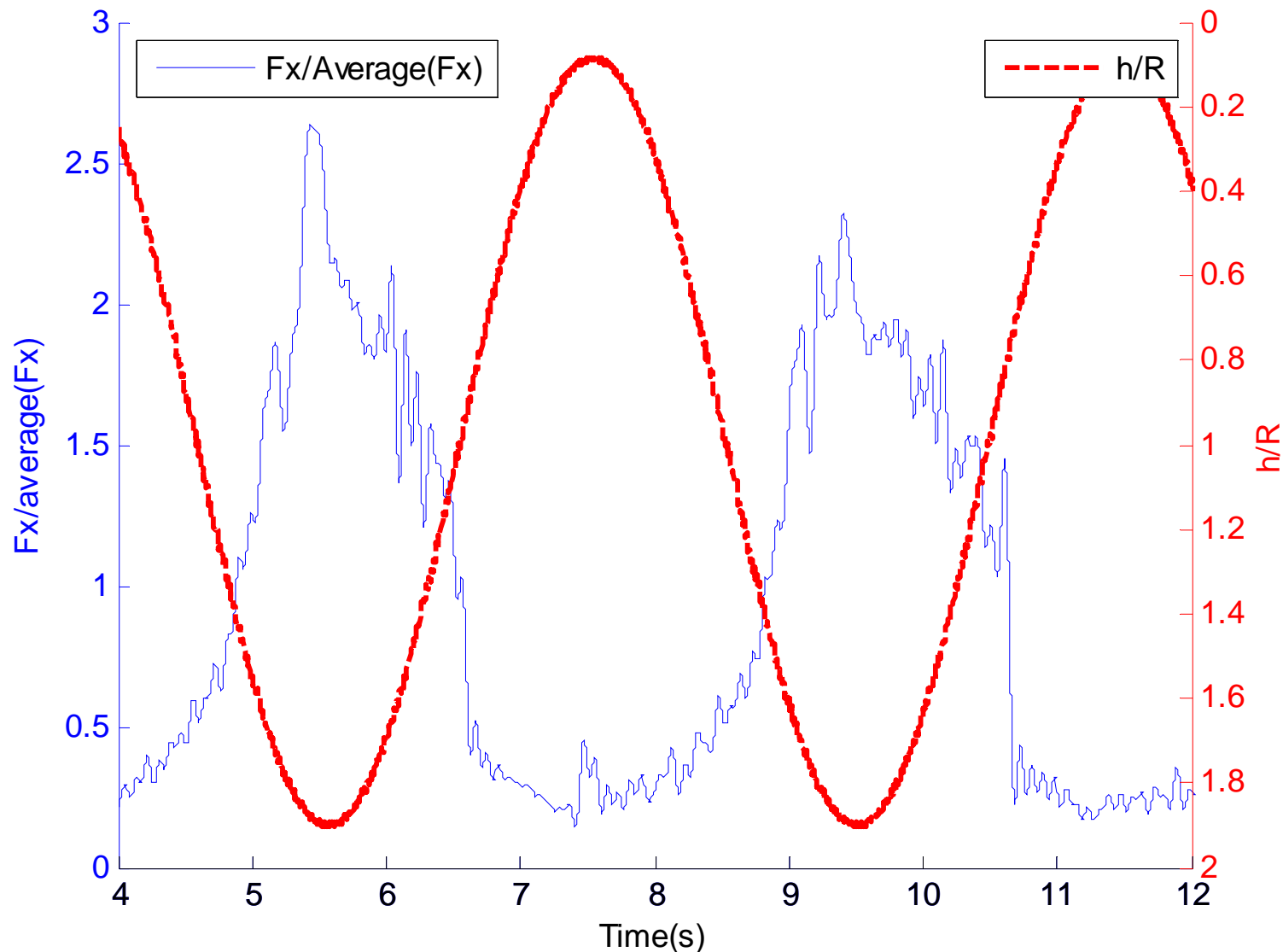
# Open thruster; Shaft freq. fluctuations in blade thrust; min. $h/R = -0.15$ ; amplitude/ $R = 2.15$ ; $T = 2s$



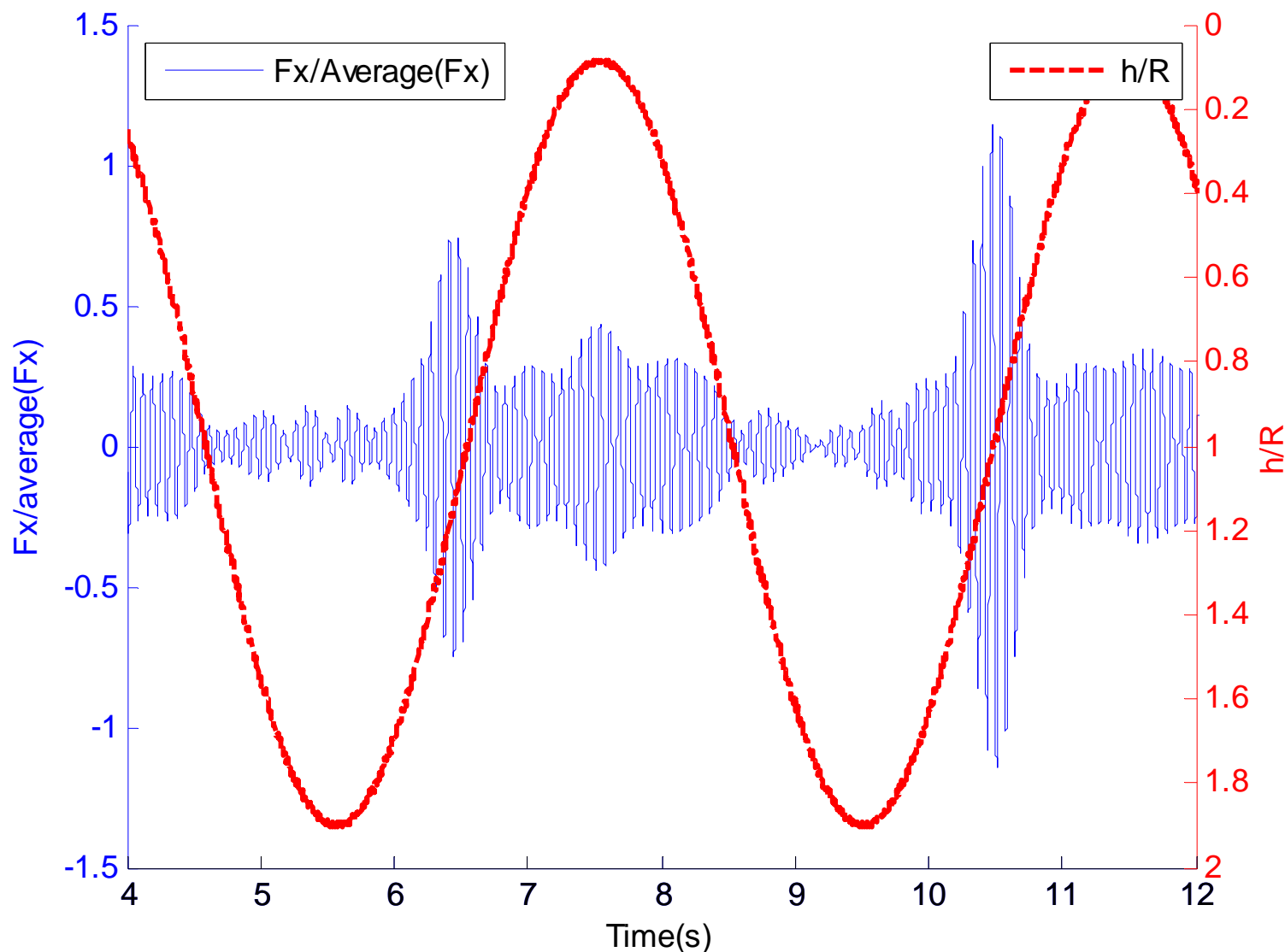
# Ducted thruster; Relative blade thrust min. $h/R=0.08$ ; amplitude/ $R=1.8$ ; $T=4$ s



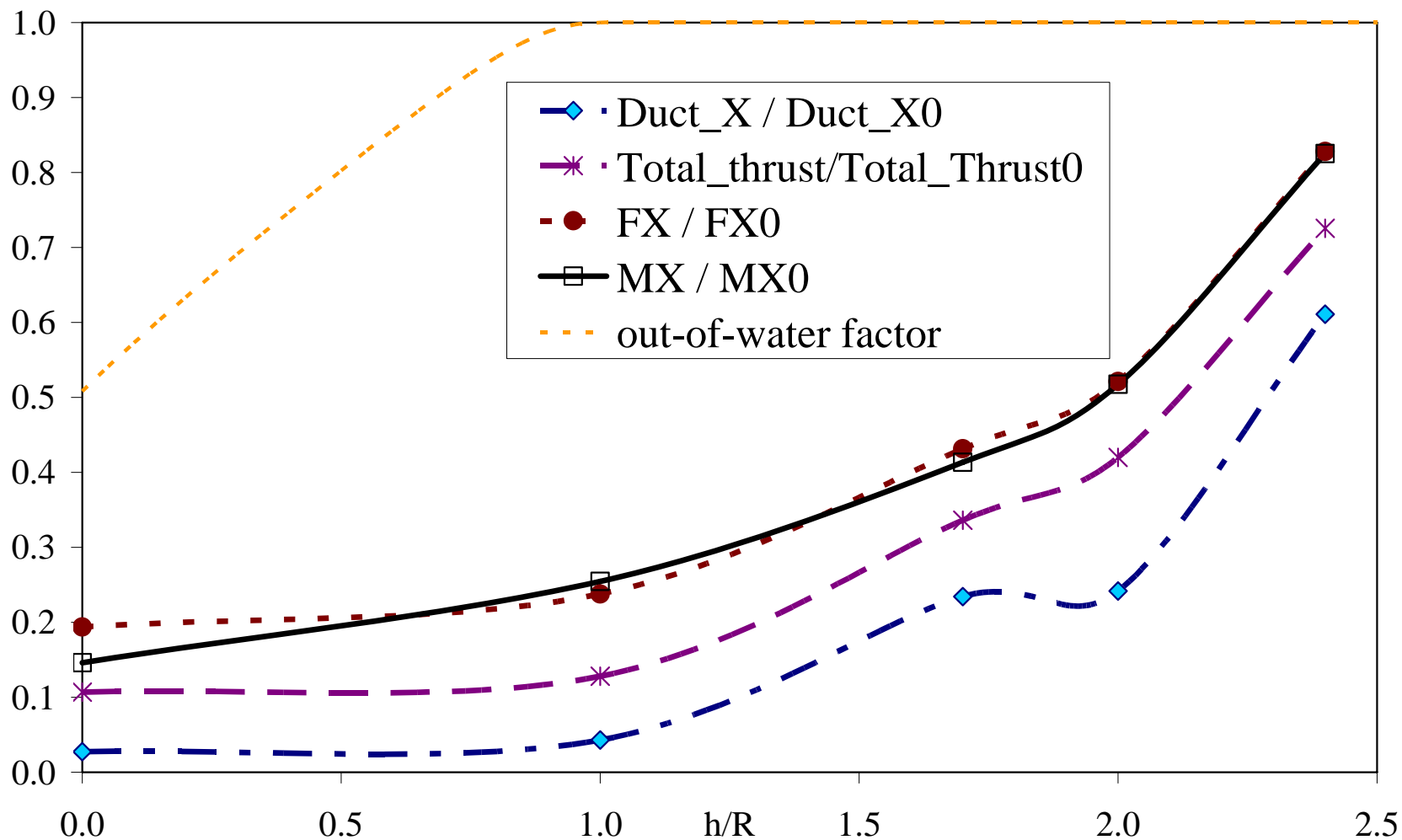
# Ducted thruster; Low pass filtered blade thrust; min. $h/R=0.08$ ; amplitude/ $R=1.8$ ; $T=4$ s



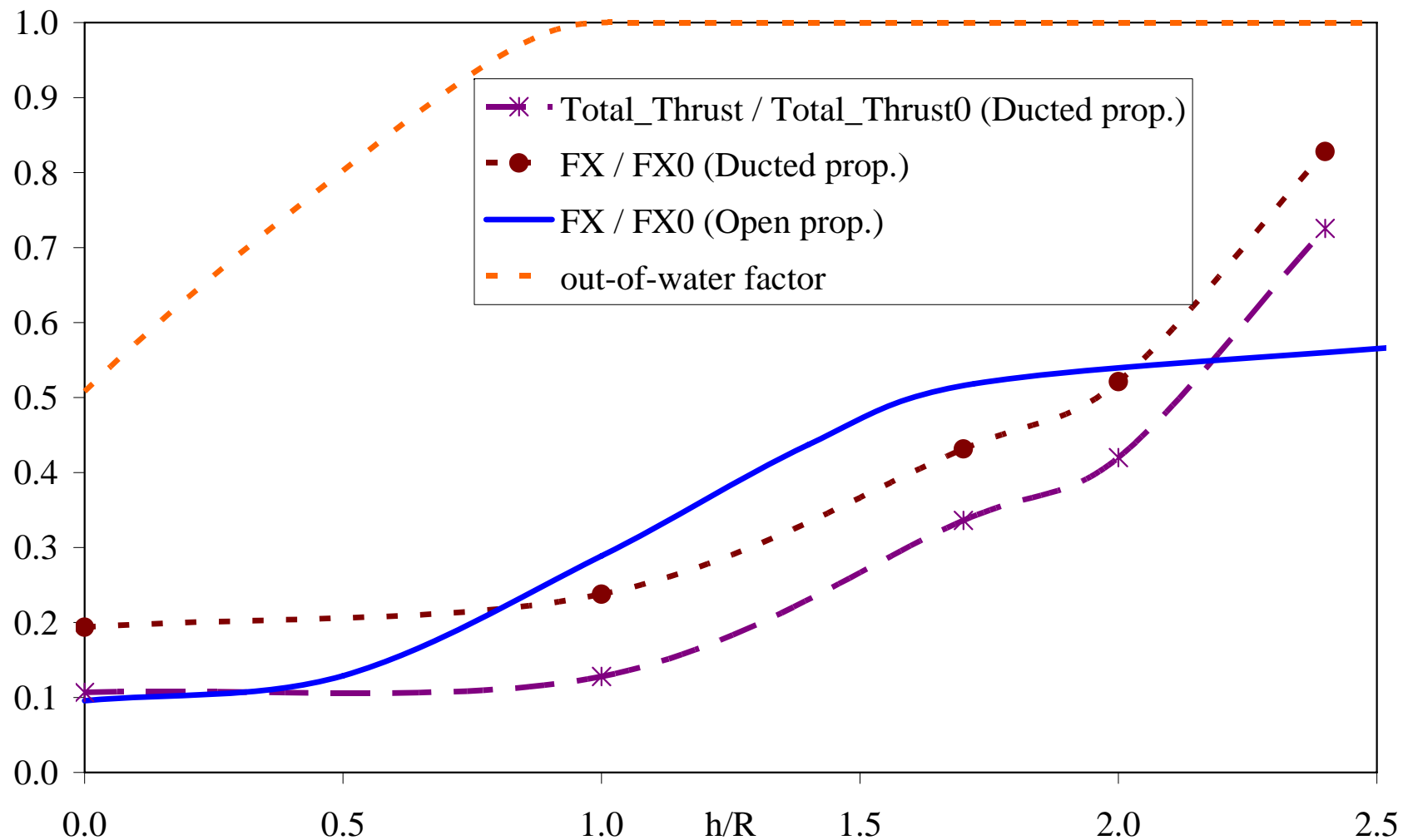
# Ducted thruster; Shaft freq. fluctuations in blade thrust; min. $h/R=0.08$ ; amplitude/ $R=1.8$ ; $T=4$ s



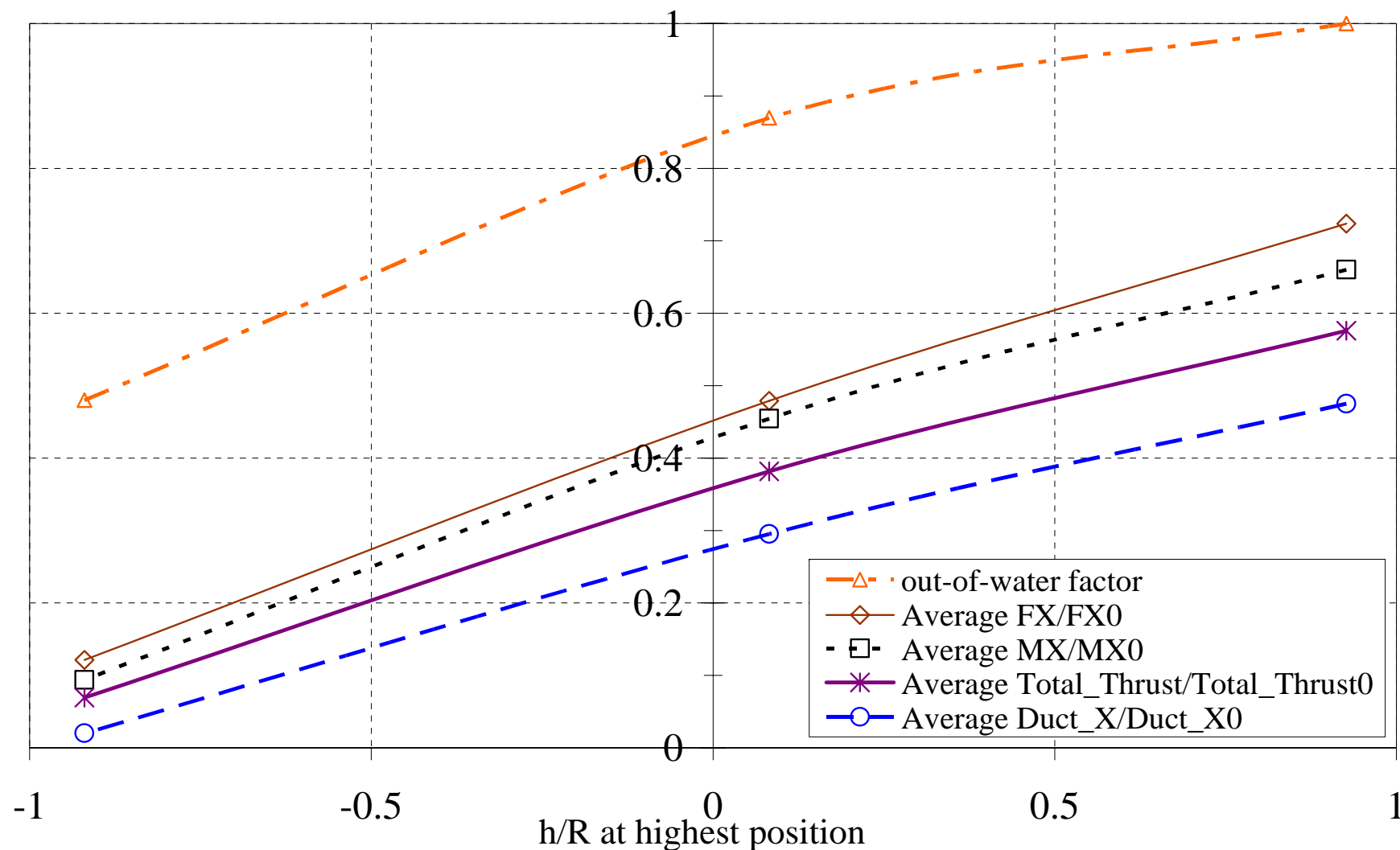
# Time-averaged ducted thruster loadings under constant immersion



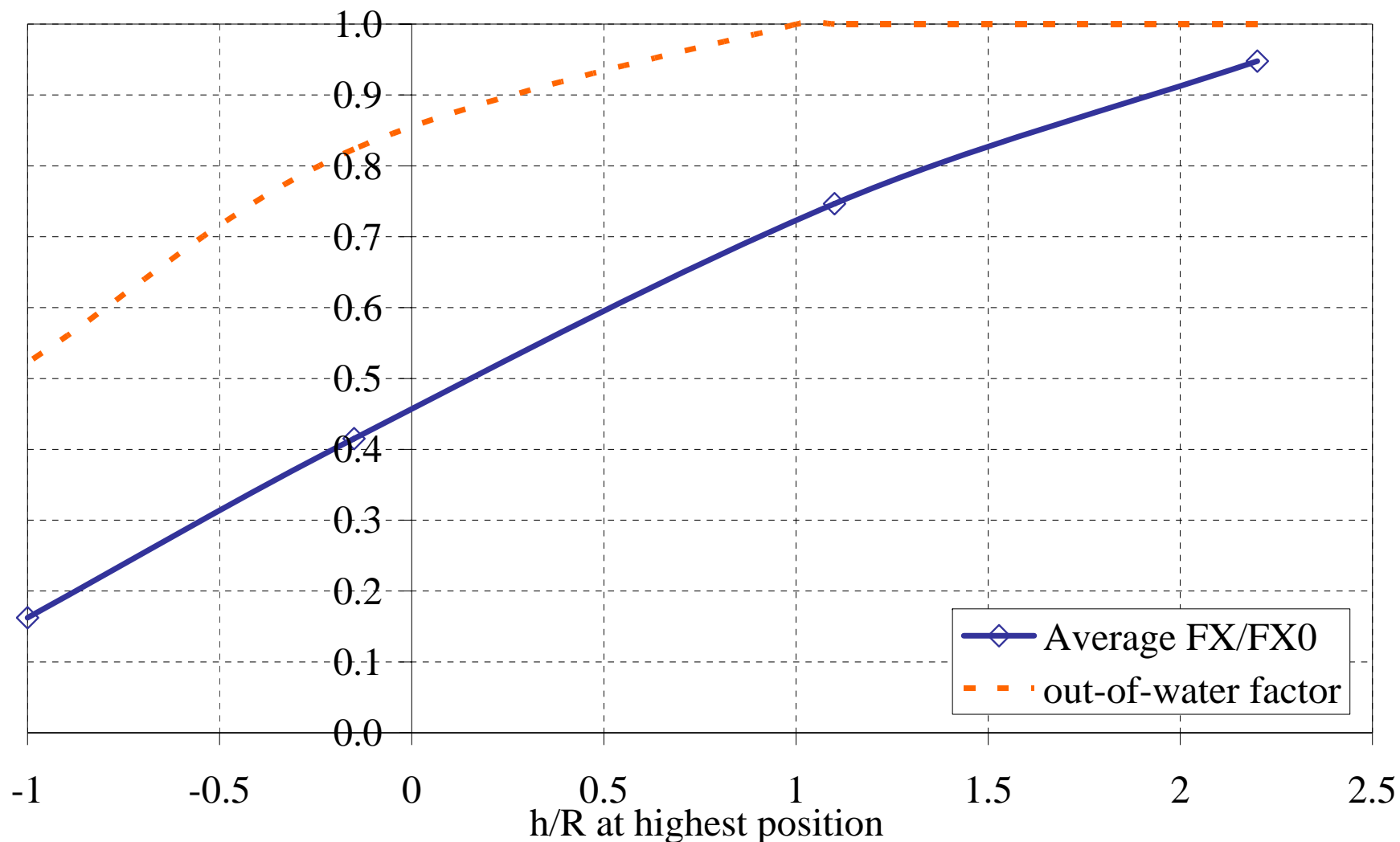
# Comparison of time-averaged loadings of ducted & open thrusters under constant immersion



# Time-averaged ducted thruster loadings under forced heave motion



# Time-averaged relative blade thrust of open thruster under forced heave motion



## Concluding remarks

- Fluctuations in blade thrust and blade torque are quite significant when a thruster is ventilated.
- Ventilation influences both the dynamic and static loadings.
- More ventilation leads to less available blade thrust, blade torque, duct thrust and consequently total thrust.
- Under ventilated conditions, fluctuations in blade torque are almost identical to fluctuations in blade thrust.
- Loading fluctuations due to ventilation must be taken into account at the design stage.