”THE RELIABLE SOLUTION
WITH
MINIMAL THRUST LOSSES”

Optimized tilting For DP Drilling Semisub Rig

Jari Ylitalo
Manager, Research and Development
Marine and Turbocharging
Propulsion Units

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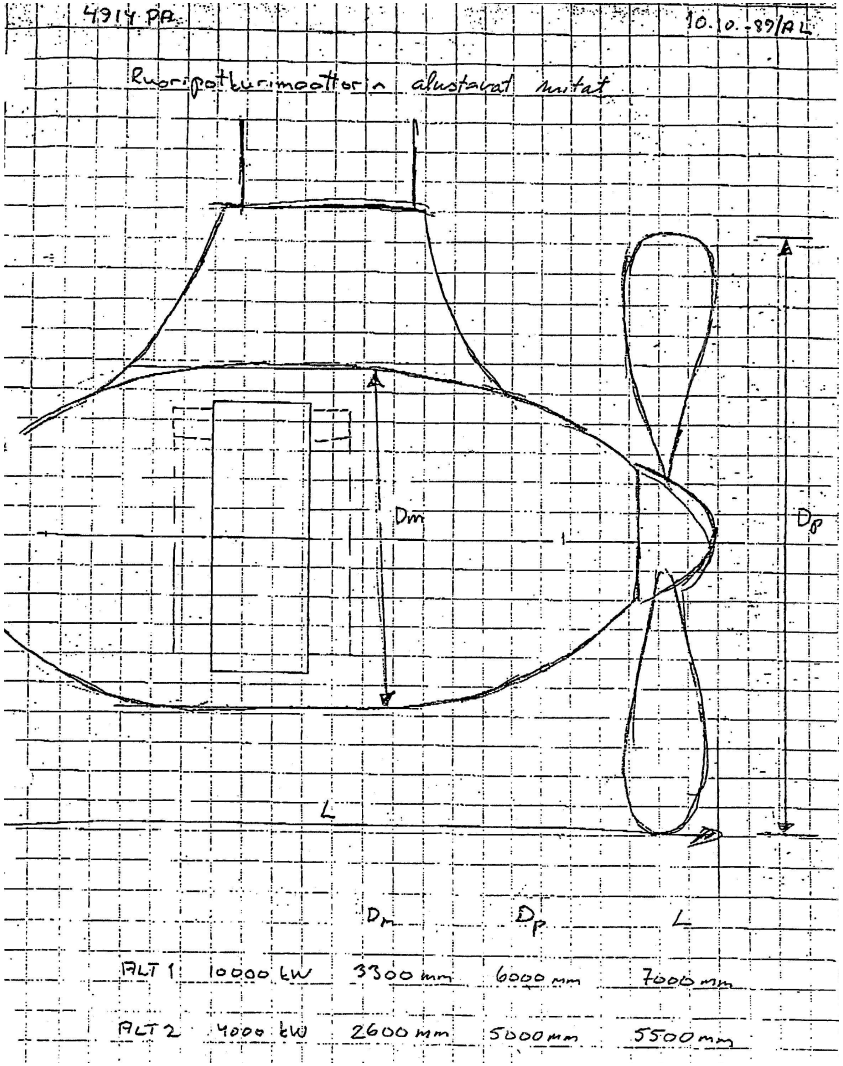
AZIPOD® - history



- Invention at late 80's
- First delivery 1989 for a waterway service vessel
- Next vessels were 16 000 DWT product tankers , equipped with one 11,4 MW Azipod®
  (first western cargo ships to navigate through the North-east Sea route)
- Cruise vessel market 1995
  (first delivery 2 x 14 MW)
- Decision of Compact Azipod development at late 90's

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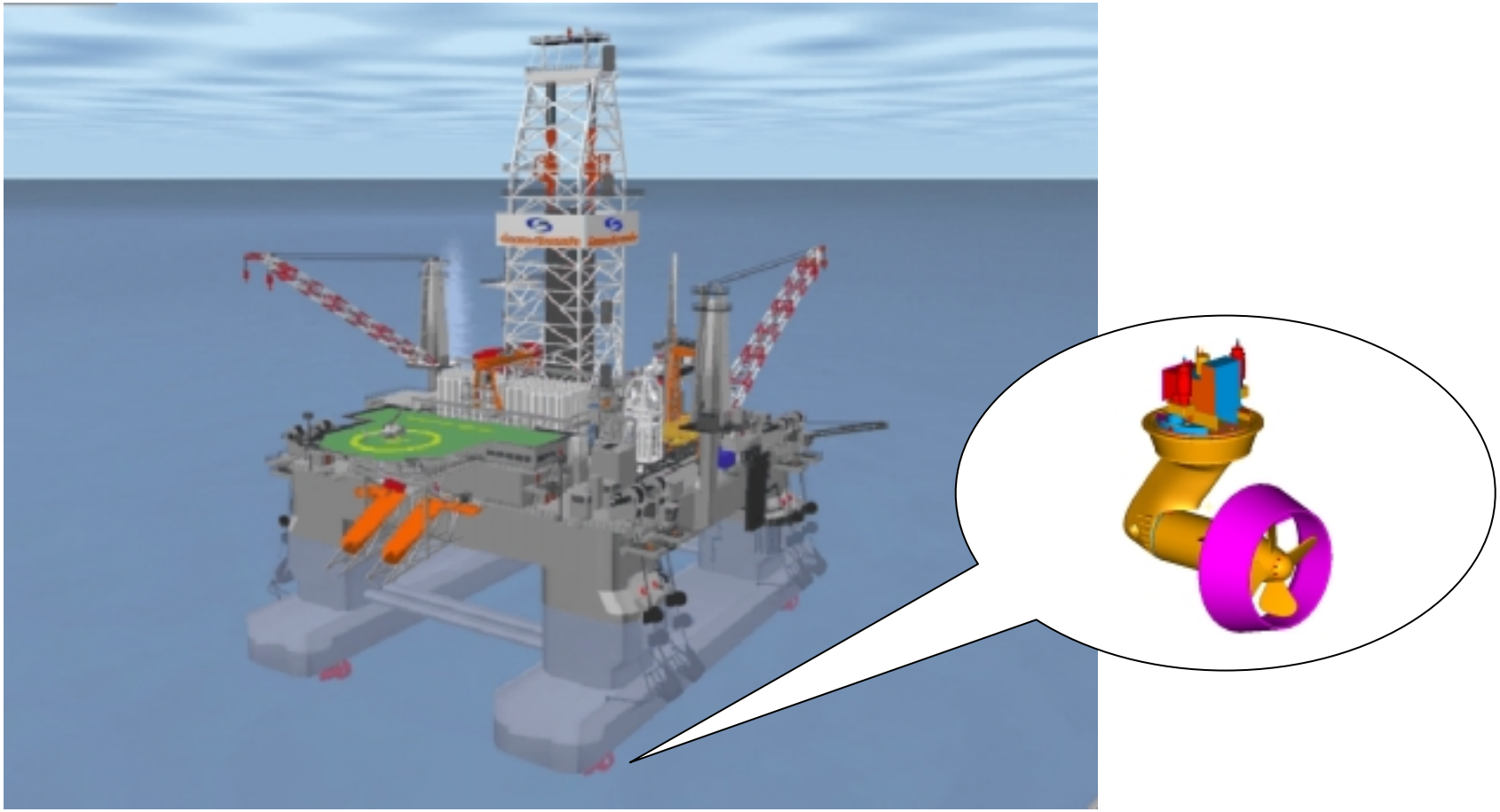
Compact AZIPOD®



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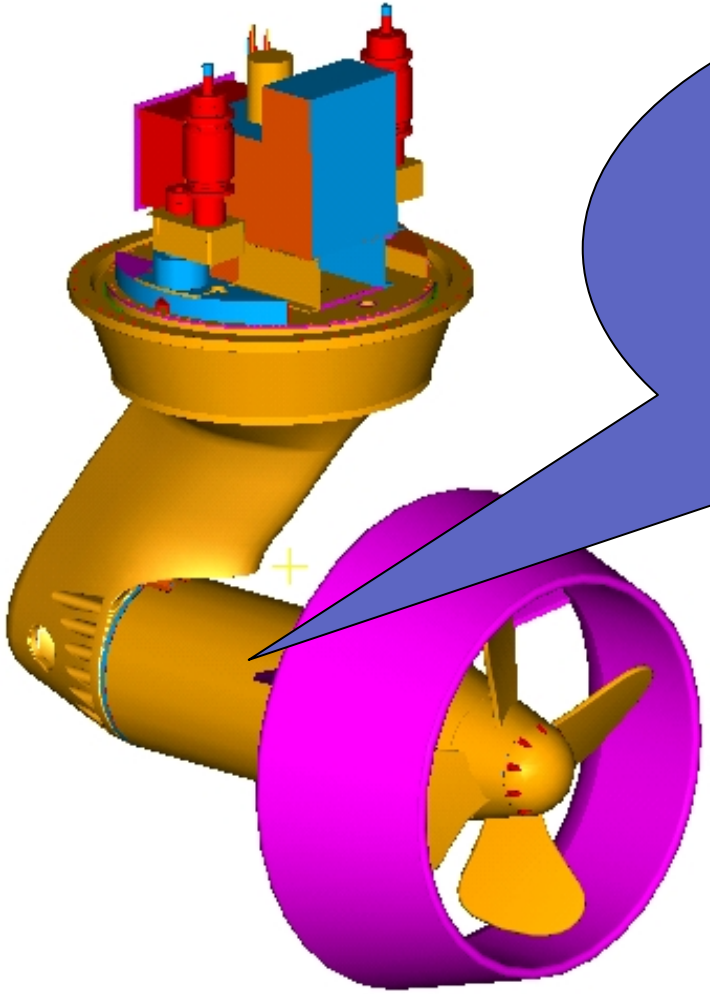
Compact AZIPOD® – some main features



- Very high efficiency el.motor
- Directly cooled to sea
  (no cooling systems required)
- Positive air pressure towards sea
- Water tolerant stator winding

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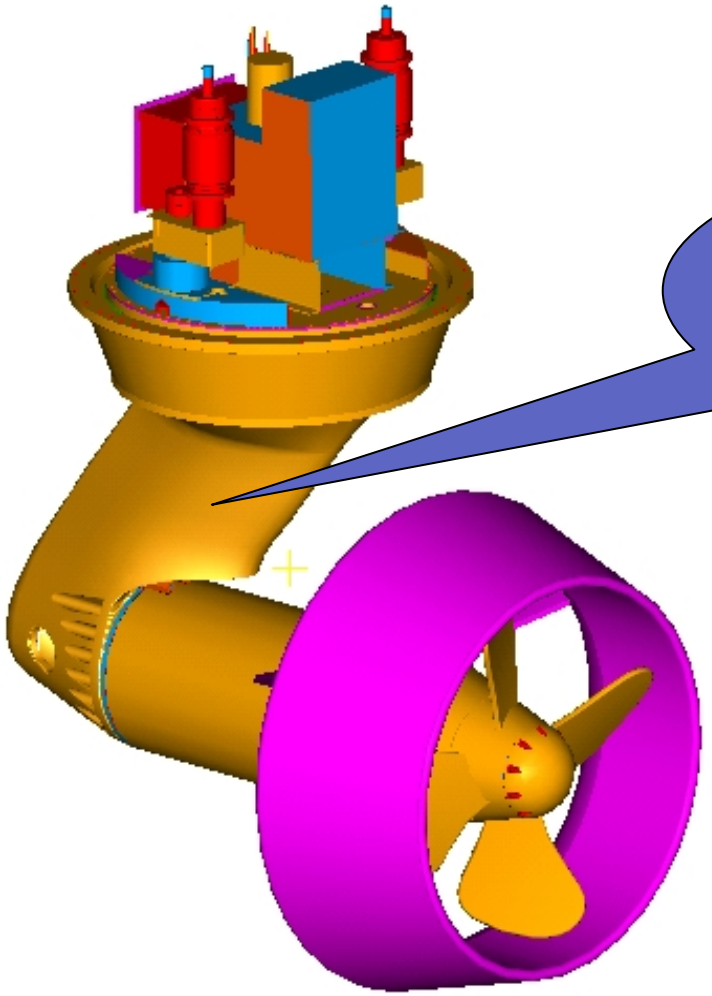
Compact AZIPOD® – some main features



- Electric power transmission
  => No gear losses

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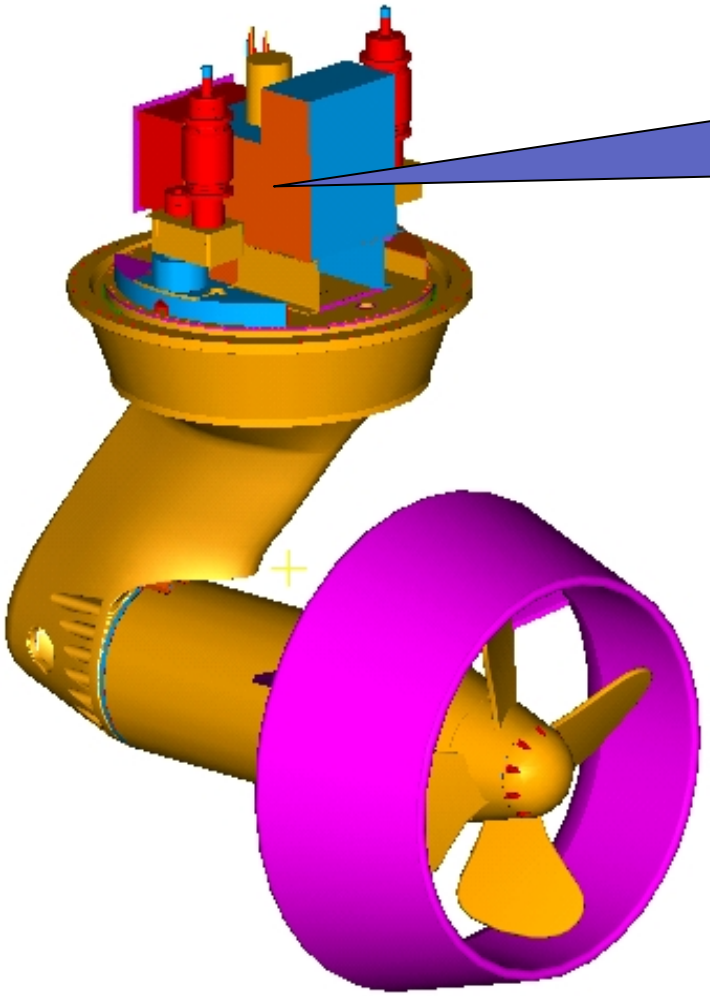
Compact AZIPOD® – some main features



- Electric steering module (only el.connections at yard)

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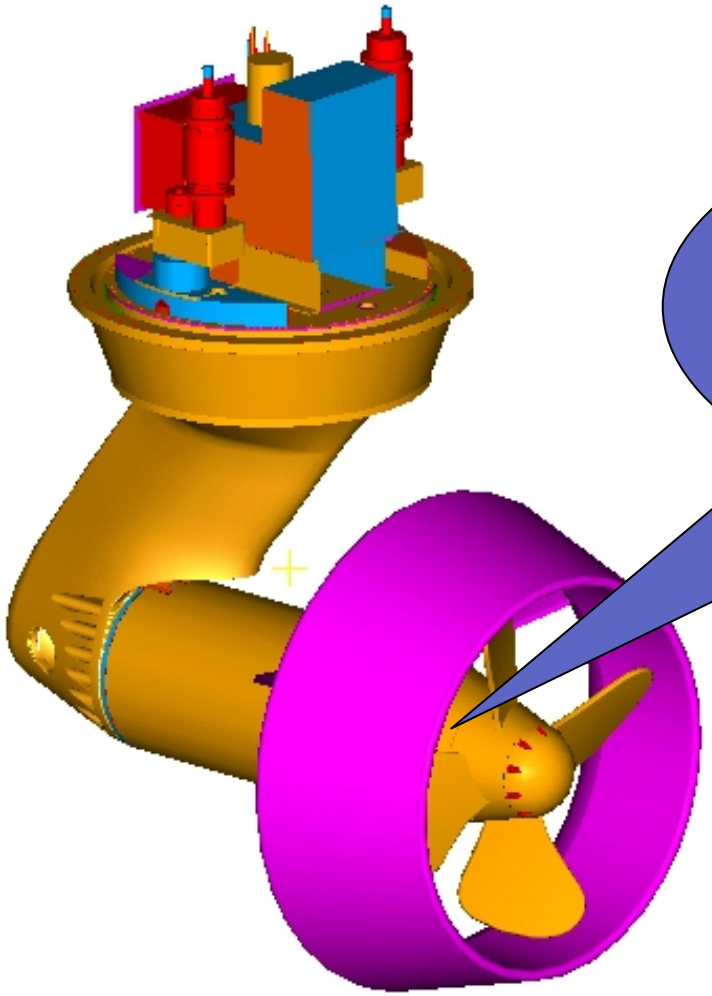
Compact AZIPOD® – some main features



- Double shaft seal system (with 2 step leakage follow up)
- No emissions (water lubricated outer seal)

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Pilot Project – multifunctional platform supply and ROV vessel

- Yard: Søviknes Verft, Norway
- Vessel: UT 745E design by Rolls Royce Marin
- Main propulsion thrusters:
  2 x 2,3 MW Compact Azipod's®
- Compact Azipod® Installation process completed in 7 days
- In operation at the Gulf of Mexico since Dec. 2001
- DP2 (Her two sister ships are designed to fulfill DP class 3)
- More than 6000 operation hrs
- Fuel consumption has been below customer expectations
- Design speed 14,5 kn fulfilled (max. recorded 16,8 kn)

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Thrust Losses in semi-submersibles

- Several sources for thrust losses
  - Friction between propeller slipstream and pontoon bottom
  - Coanda effect
  - Thruster to Thruster interaction
- It is possible to reduce these losses by directing the jet from thruster downwards

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A Quest For Minimal Thrust Losses

- A joint study between GSF and ABB
- Krylov Ship Research Institute (KSRI) contracted to perform the work
- Intention to find optimum tilt angle
- This goal to be reached via applying both computational method and model scale experiments

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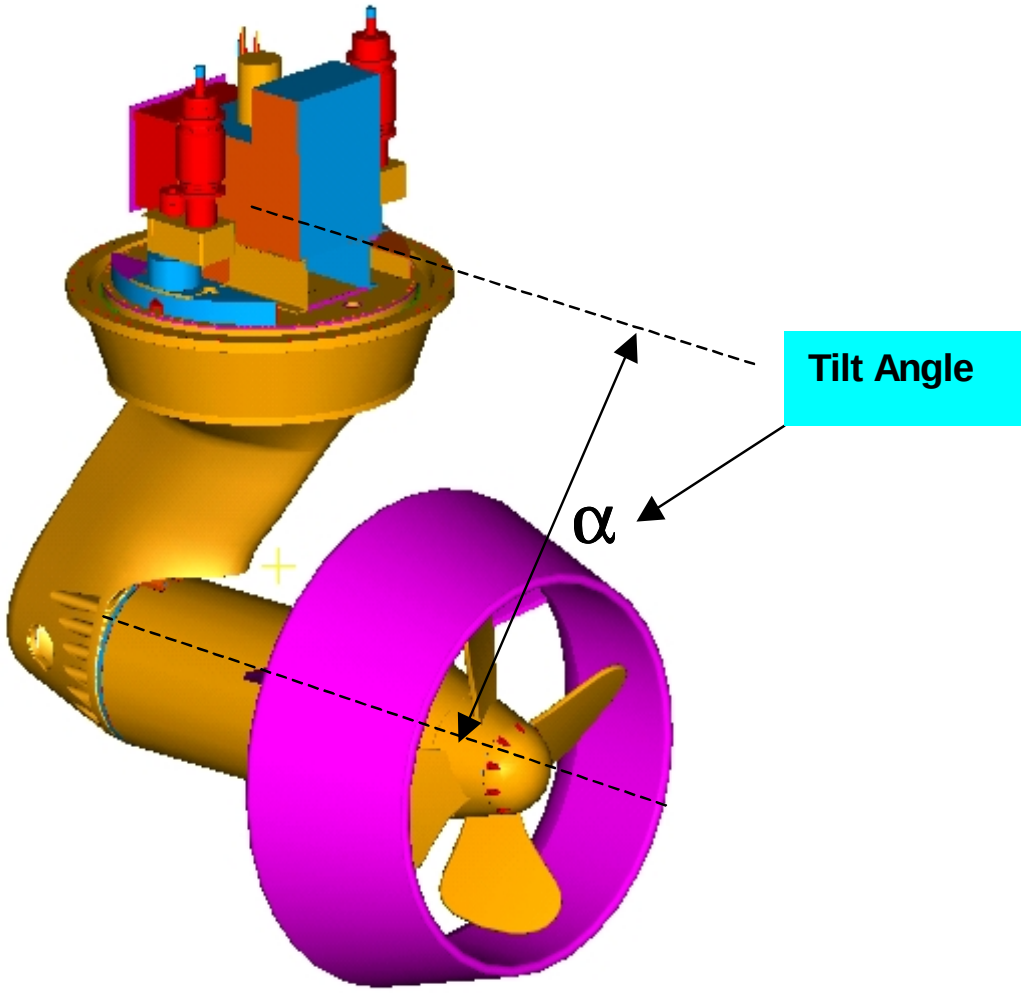
Definition Of Tilt Angle

- adjusting the angle of the propeller shaft line relative to horizontal



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Computational Study - 1

- Computational flow simulation
- The method applied is RANS (Reynolds Averaged Navier Stokes)
- In order to be able to evaluate the scale effects
  - Viscous forces (Friction) are scaled according to Reynolds number (Rn)
  - Different Rn values for model ($Rn = 4.405 \times 10^6$) and Full scale ($Rn = 1.113 \times 10^8$)

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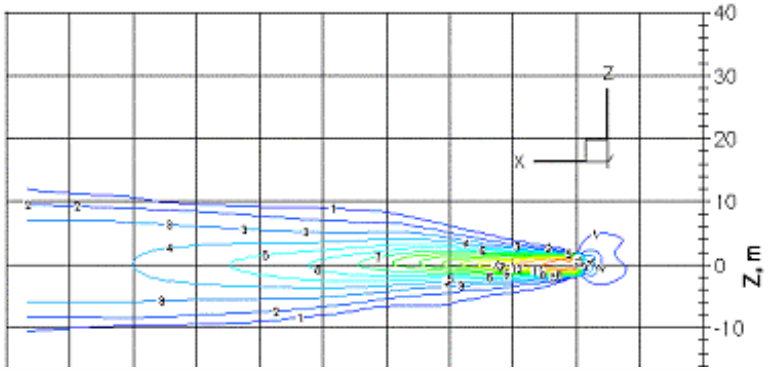
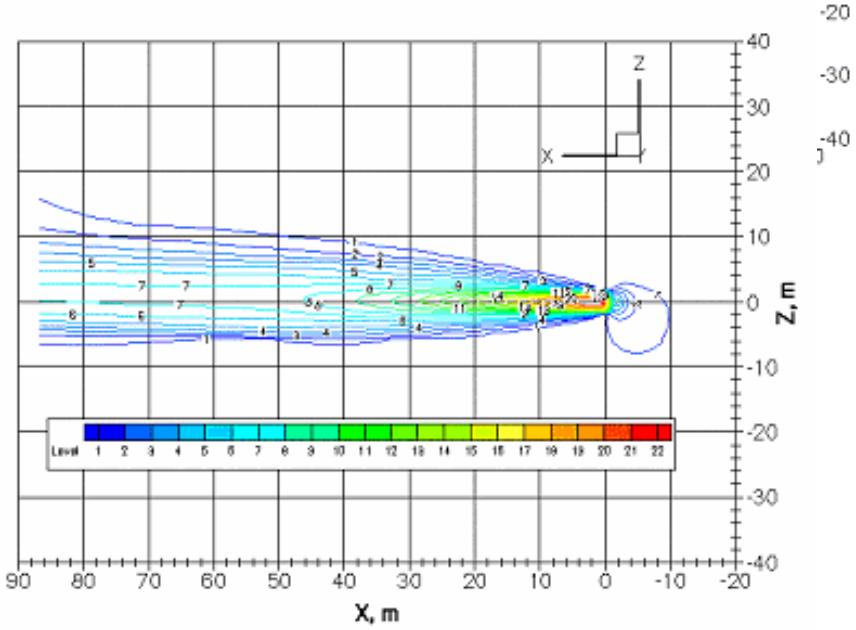
Computational Study – 2

- Propeller jet in open water condition

Model scale



Full scale



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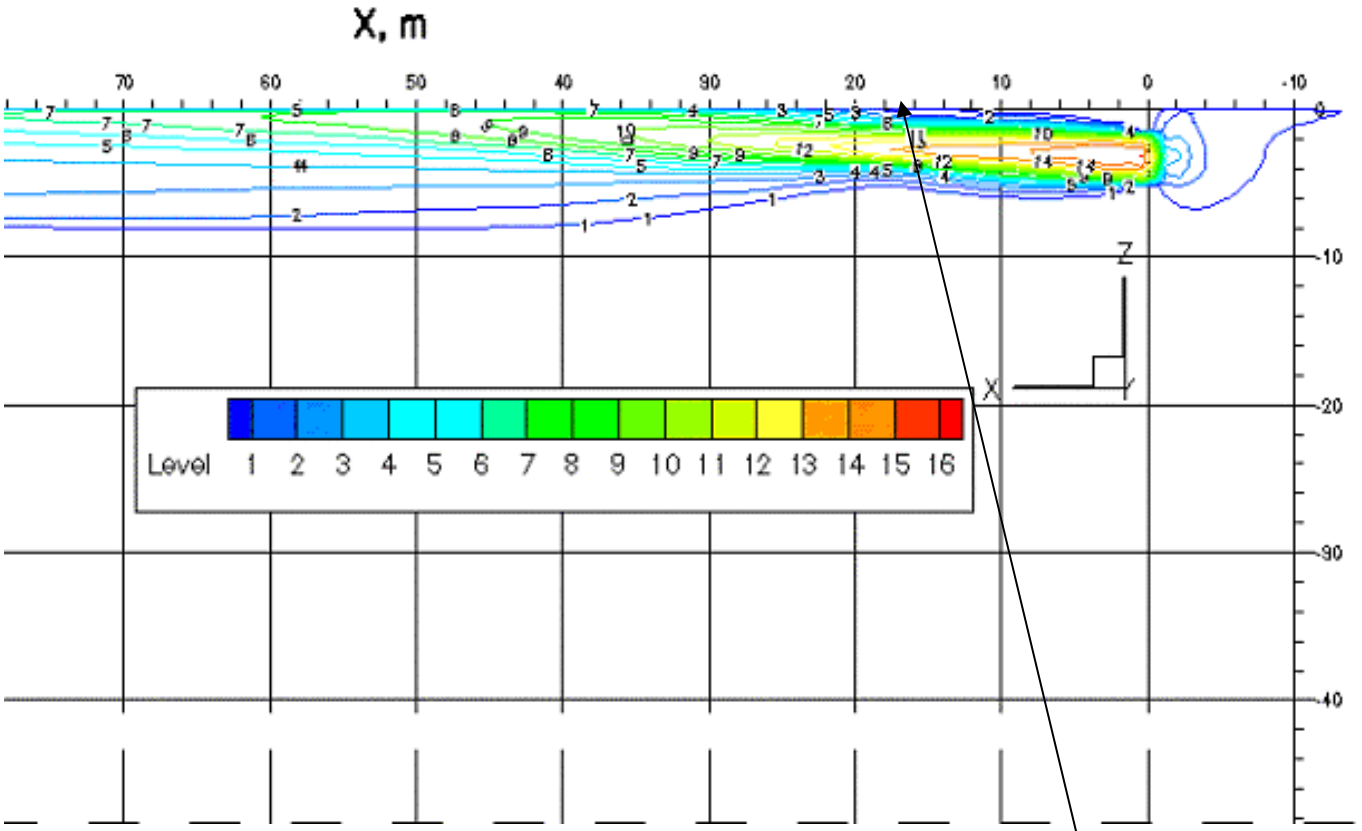
Computational Study – 3

- Propeller jet under infinite plate



No friction before this point

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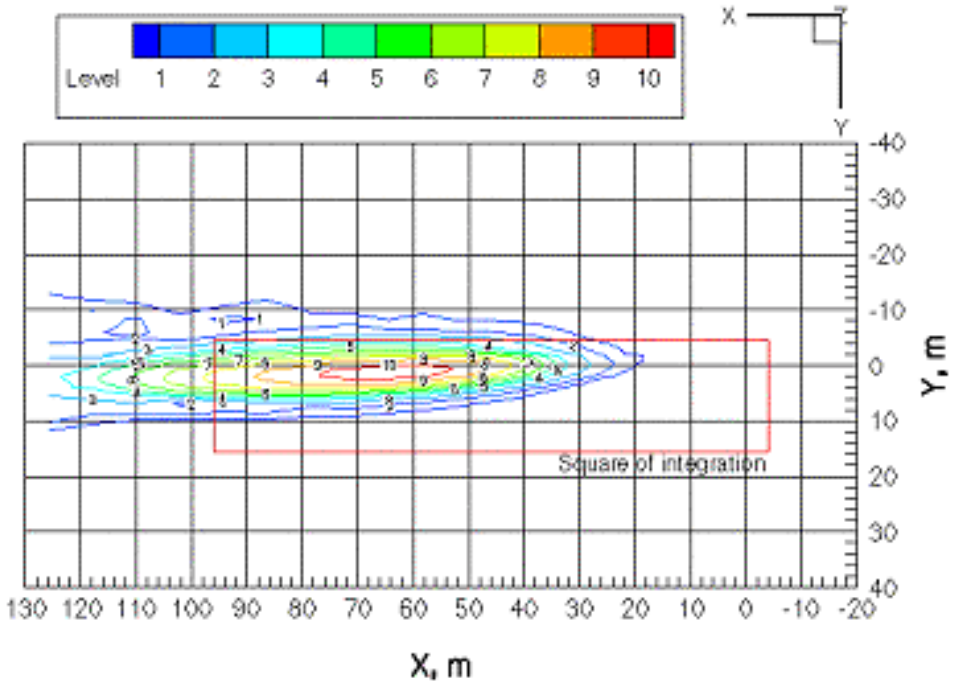
Computational Study – 4

- Calculation of thrust losses
  - Tensions integrated over integration area
    - Model scale losses 5%
    - Full scale losses 2.5%
  - Scale effects significant



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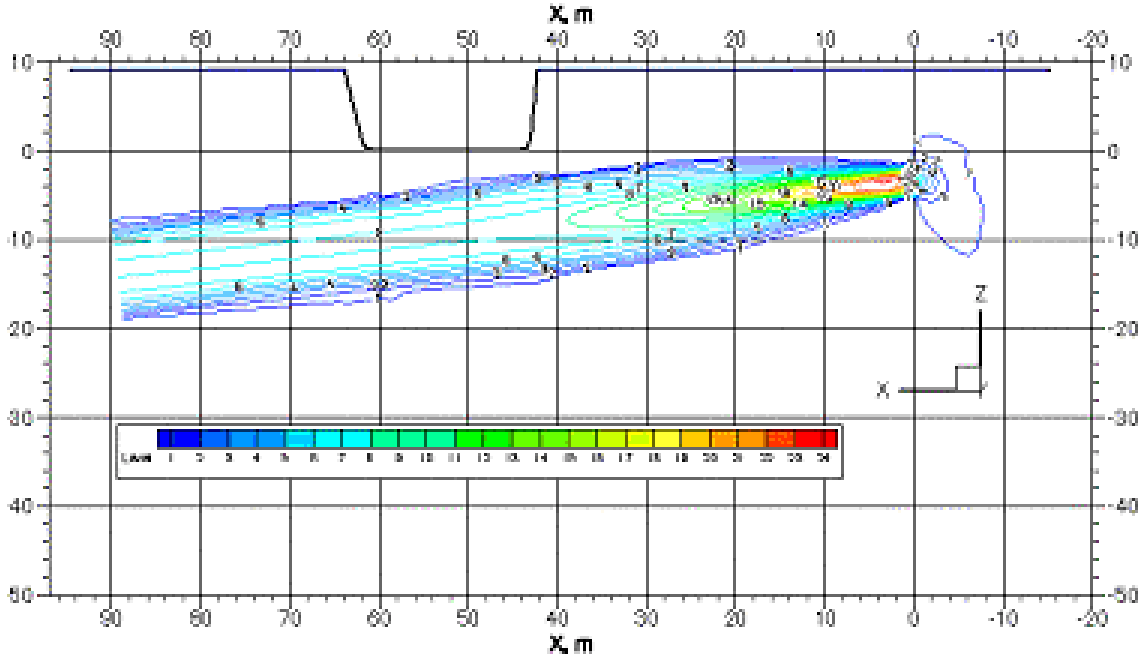
Computational Study – 5

- Unit with 7 degrees tilt angle in full scale
  - No interaction with other pontoon



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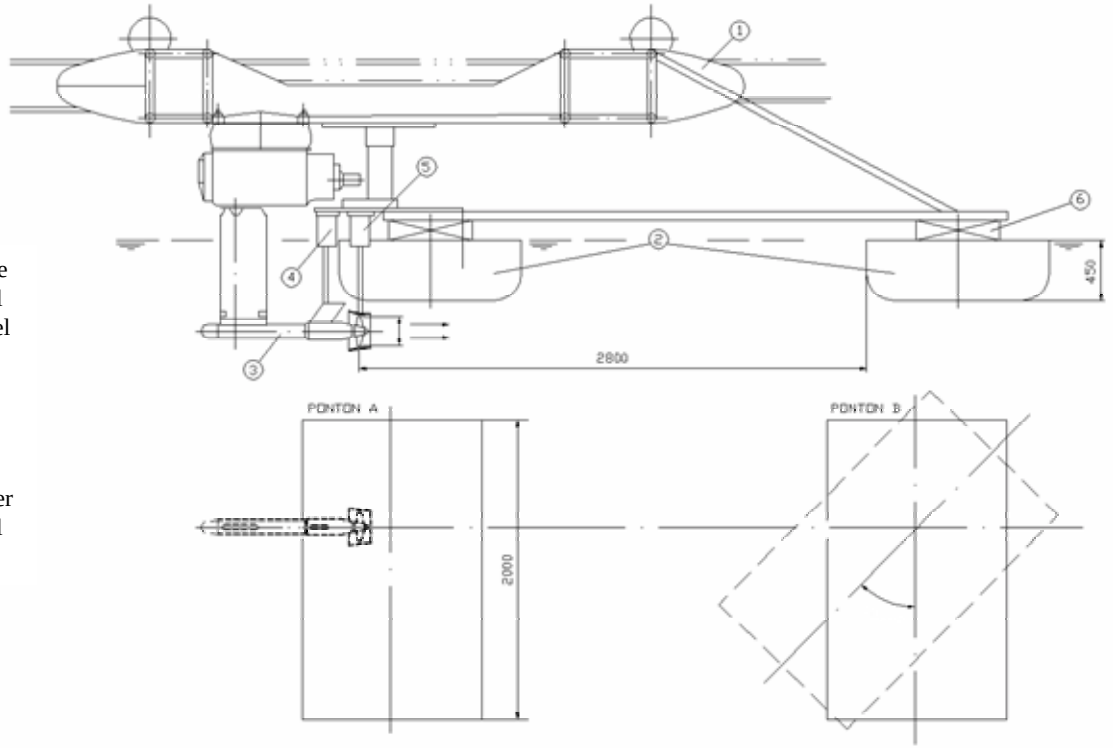
Experimental Study - 1

- Test setup

1. towing carriage
2. pontoon model
3. propeller model dynamometer
4. pod model resistance transducer
5. nozzle axial force transducer
6. pontoon model dynamometer



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Experimental Study - 2

- Thruster hull interaction divided into smaller tasks
  - Interaction of thruster with pontoon where thruster is attached
  - Interaction of thruster with other pontoon
  - Interaction of thruster with pontoons when other thrusters at place
- Different tilt angles compared

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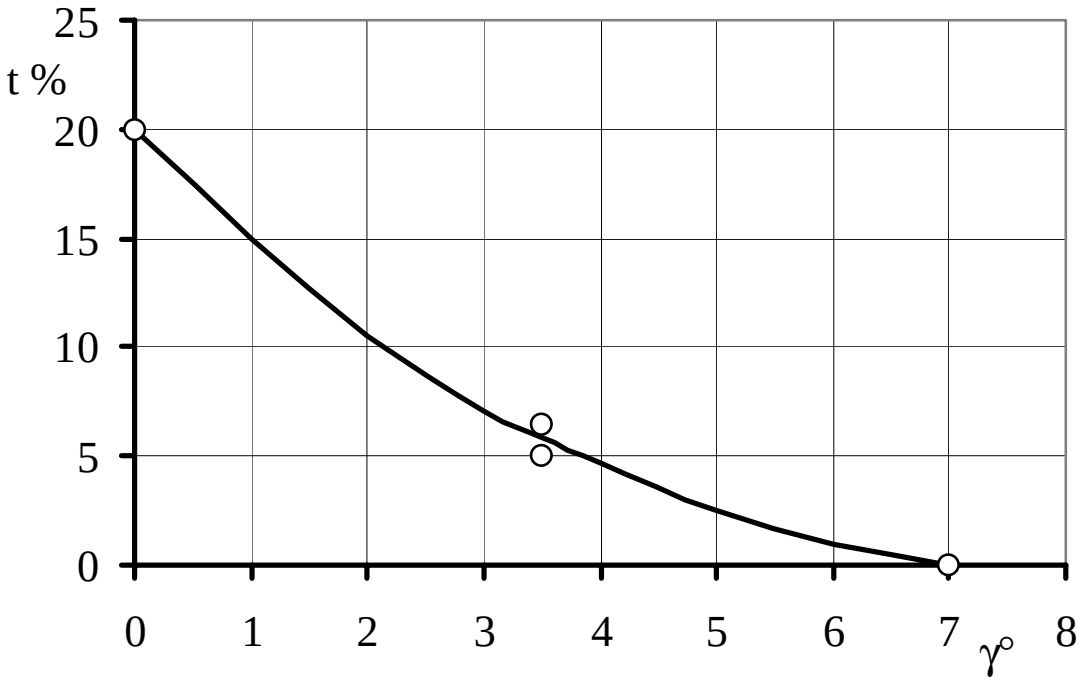
Experimental Study – 3

- Thruster jet directed perpendicular to the pontoon cl



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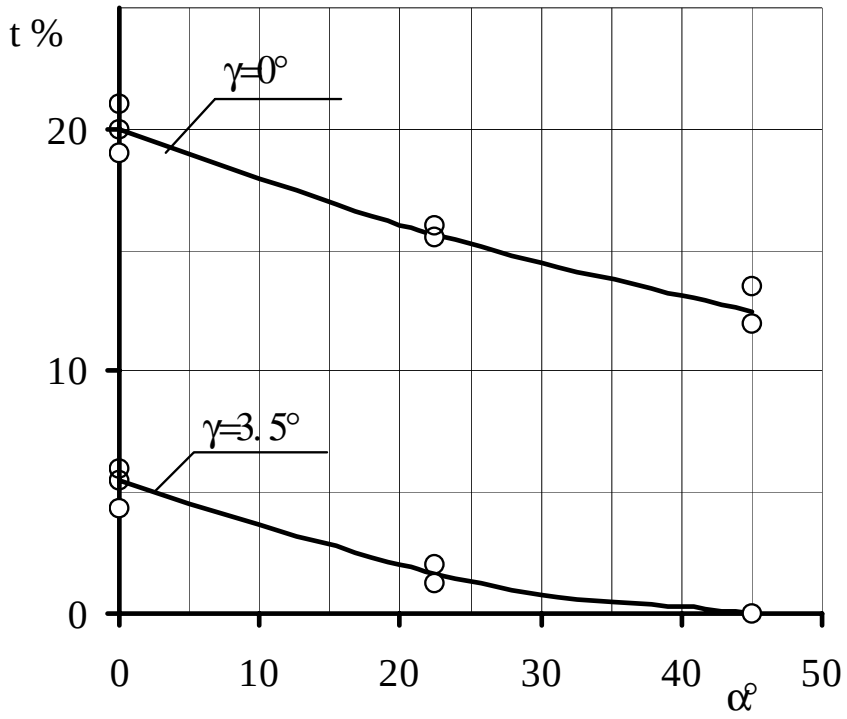
Experimental Study – 4

- Interaction with other pontoon with different azimuth angles
  - With 7 degrees tilt zero losses



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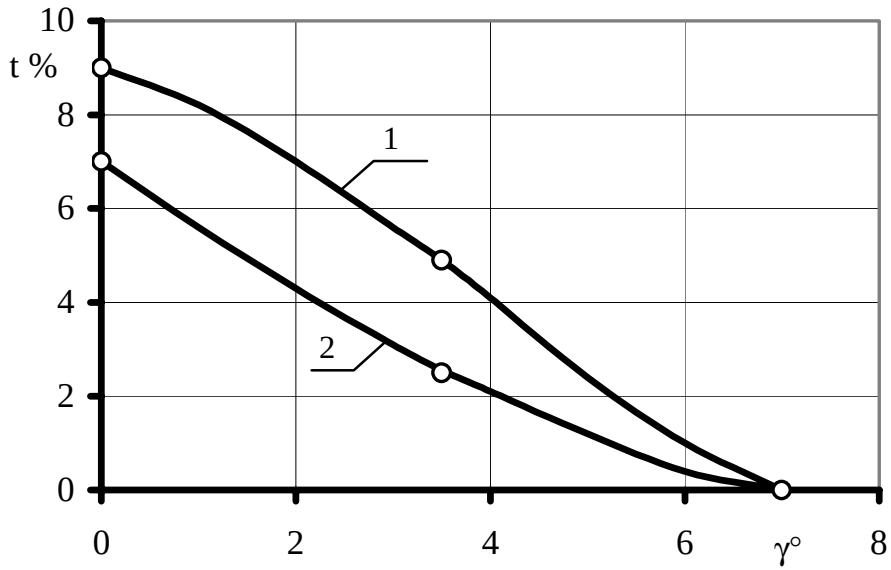
Experimental Study - 5

- Interaction with pontoon when thrust is directed along the pontoon
  - With 7 degrees no losses



1-with POD on another end of the hull;
2-without POD

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Conclusions Of The Study

- Scale effects significant
- Computational results slightly over estimating
- The Coanda effect not found
- Up to 30% improvement by applying the 7 degree tilt angle compared to untilted unit

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Comparison To Mechanical Thrusters - 1

- With podded propulsion it is possible to optimize the thrust by tilting the motor module (not the nozzle)
- This is possible also with tilted nozzle, but
  - It may decrease the propeller/nozzle efficiency
  - The tilting angle is limited

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Comparison To Mechanical Thrusters – 2

- Comparison to thruster without tilting of the nozzle
  - With untilted thruster one may have up to 30% losses compared to 0% losses with tilted podded thruster
  - Typically the range of losses without tilt is some 10 to 20% of unit thrust, compared to 0 % losses with tilted podded thruster

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Comparison To Mechanical Thrusters – 3

- Comparison to Mech. Thruster with tilted nozzle
- Based on data presented by Vartdal & Garen (DPC2001)
  - Comparison is not straight forward as positioning of thrusters is different in these installations

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Comparison To Mechanical Thrusters – 4

- Comparison to Mech. Thruster with tilted nozzle ctd’
  - When thruster directed along the hull
    - For 8° tilted nozzle the losses are 4 % to 5 % of unit thrust
    - For podded thruster with 7° tilt angle losses are 0 % of unit thrust

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Comparison To Mechanical Thrusters – 5

- Comparison to Mech. Thruster with tilted nozzle ctd’
  - When thruster jet is directed perpendicular to pontoon (towards other pontoon)
    - For 8° tilted nozzle the losses are 4 % to 6 % of unit thrust
    - For Compact Azipod with 7° tilt angle losses are 0 % of unit thrust

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Comparison To Mechanical Thrusters – 6

- Comparison to Mech. Thruster with tilted nozzle ctd'
  - Reduction in merit coefficient (i.e.. In thrust without presence of hull)
    - For 8° tilted nozzle the reduction is 2 %
      - Due to fact that nozzle is not working as it has been designed
    - For Compact Azipod with 7° tilt angle a reduction of 0.8 %
      - Due to fact that thrust is directed a bit upwards from horizontal plane

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Conclusions

- Compact Azipod is structurally simple thruster with only few moving parts and possibility to tilt motor module
- Tilting the motor module gives hydrodynamically a 4 to 6 % advantage in thrust compared to tilted nozzle
- Both model scale and full scale condition calculations give a clear indication that the scale effects have significant importance
- With 7º tilt angle it has been possible to eliminate thruster hull interaction effects in Development Driller
- Lack of gear wheels decreases power demand additional 4 to 5 %
- Compact Azipod requires up to 12 % less installed power than mechanical thruster with tilted nozzle…

  and even up to 20-30 % less power than mechanical thruster without tilted nozzle

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