## Propeller design with induction factors

# IndFact

Designing wake adapted propellers, with or without unloaded tip and/or hub, is an activity that needs fast and flexible tools to generate the hydrodynamical characteristics and detailed geometrical description in agreement with the variation and evaluation of the input variables. The propeller design program INDFACT is such a tool.

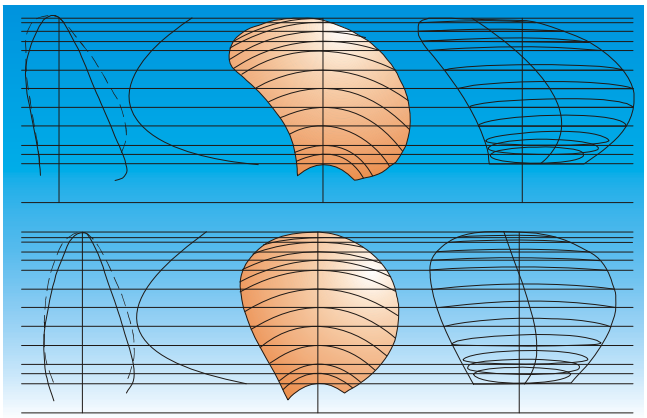
## Computational approach

INDFACT is a lifting line program which implies a hydrodynamic model of the propeller using straight bound vortices for the blades of the propeller and a series of free vortices behind these blades, positioned on concentric cylinders and having constant pitch. The on-flow to the blades due to bound and free vortices is calculated on the basis of the Lerbs' induction factor method; the induction factors themselves are according to Morgan and Wrench.

*Stress check according to Romsom*

| | STRESSES IN N/MM2 | | | | | |
|---|---|---|---|---|---|---|
| | HYDRODYN. | | CENTRIFUGAL | | SUMMATION | |
| X | TENSILE | COMPR | TENSILE | COMPR | TENSILE | COMPR |
| .20 | 50.39 | 52.77 | 8.88 | .10 | 59.27 | 52.86 |
| .30 | 48.03 | 50.29 | 8.90 | 1.12 | 56.93 | 51.41 |
| .40 | 48.02 | 50.28 | 7.96 | 1.04 | 55.98 | 51.32 |
| .50 | 49.41 | 51.73 | 7.04 | .96 | 56.45 | 52.69 |
| .60 | 51.35 | 53.77 | 5.44 | .22 | 56.80 | 53.99 |
| .70 | 53.79 | 56.32 | 4.75 | .53 | 58.54 | 56.84 |

The program takes into account the radial distribution of the circumferential mean axial and tangential velocity.



*Propellers with varying skew*

The propeller, as characterised by hydrodynamic variables, has to be completed to geometrical characteristics. INDFACT incorporates an iteration procedure which combines cavitation on both sides, with a strength calculation. It eventually leads to chord length, maximum section thickness and camber.

The detailed geometry of the propeller is corrected by using the MARIN polynomials for the lifting surface correction factors according to Morgan. These corrections are applied to the maximum camber due to loading and to the pitch due to thickness. The design program is directed to the use of the parabolic mean line.

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MARIN
P.O. Box 28

6700 AA Wageningen
The Netherlands

T +31 317 49 39 11
F +31 317 49 32 45

E info@marin.nl
I www.marin.nl

## Input/output

With a minimum input the program generates information on the efficiency losses due to axial acceleration, rotation of the flow behind the propeller and section drag. The complete geometry is determined in accordance with required strength. The accuracy with respect to performance is very acceptable, and generally within some per cent. It does, however, not give information on unsteady behaviour of the propeller in the wake of the ship. For this the MARIN propeller analysis program ANPRO has to be used.

*Example of output*

| X | CH | TETS | TR-IK | TR-UK | PP/DP | TMAX | FMAX |
|---|---|---|---|---|---|---|---|
| .200 | .3756 | 15.5000 | .1475 | -.2281 | .7025 | .0682 | .0152 |
| .250 | .4232 | 2.8656 | .2023 | -.2209 | .8145 | .0626 | .0141 |
| .300 | .4647 | -5.4978 | .2538 | -.2109 | .8964 | .0573 | .0132 |
| .400 | .5294 | -14.1729 | .3384 | -.1910 | .9685 | .0471 | .0118 |
| .500 | .5676 | -16.0958 | .3884 | -.1791 | 1.001 | .03787 | .0110 |
| .600 | .5338 | -13.7478 | .3991 | -.1846 | 1.0037 | .0292 | .0108 |
| .700 | .5853 | -8.4525 | .3696 | -.2157 | .9834 | .0215 | .0109 |
| .800 | .5626 | -1.0000 | .2917 | -.2709 | .9430 | .0167 | .0105 |
| .850 | .5325 | 3.3688 | .2290 | -.3035 | .9145 | .0144 | .0100 |
| .900 | .4759 | 8.1002 | .1432 | -.3327 | .8834 | .0120 | .0086 |
| .950 | .3685 | 13.1550 | .0218 | -.3468 | .8513 | .0096 | .0056 |
| .975 | .2817 | 15.7931 | -.0594 | -.3411 | .8340 | .0084 | .0032 |

| | | | | |
|---|---|---|---|---|
| NO. OF BL. = 4 MM | | TETS HUB = 15.500 DEG | | |
| DIAMETER = 1490.0 | | TETS TIP = 18.500 DEG | | |
| PP/DP = .9354 | | TETS SNY = 1.000 DEG | | |
| AE/AO = .6962 | | X-SNY = .800 | | |
| MASS = 221.6 KG | | TETS TOT = 34.625 DEG | | |
| GD2 = 135.4 KGM2 | | | | |
| PROPELLER CHARACTERISTICS | | CTH = .8815 | KT = .1627 | |
| THRUST = 72.94 KN | | CP = 1.3980 | KQ = .0281 | |
| TORQUE = 18.81 KNM | | | ETAB = .6305 | |
| POWER = 1112.67 KW | | | | |

## References


- Lerbs, H.W.; 'Moderately Loaded Propellers with Finite Number of Blades and an Arbitrary Distribution of Circulation', SNAME, Vol. 60, 1952.
- Van Gent, W. and Van Oossanen, P.; 'Influence of Wake on Propeller Loading and Cavitation', Second Lips Propeller Symposium, 1973.



For more information please contact the Maritime Simulation & Software Group;

T +31 317 493 237

E msg@marin.nl