

PROPELLER GEOMETRY AND STRENGTH ASSESSMENT SERVICE

BETA RELEASE

From ship particulars to a propeller solid model and a strength screening.

From the principal particulars of a fixed-pitch marine propeller, the service produces the three-dimensional solid model, the manufacturing sections and a finite-element static strength screening with a mesh-convergence record. The geometry may be used for casting or additive manufacturing; the strength screening applies to the cast condition and may be re-analysed independently.

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generation of blade geometry from particulars

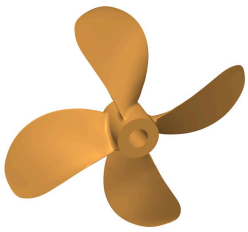
20–80 min
three-mesh strength study on a single workstation

0.36–0.49 M
quadratic tetrahedral elements on the finest mesh

4 of 4
example propellers meshed at all three levels at the first attempt

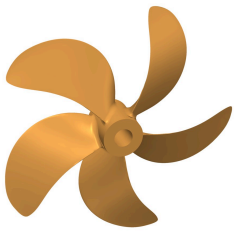
Four example propellers, generated and assessed for this brief

Illustrative designs generated from the stated particulars; not delivered products. All four results are reproduced as reported, including one that exceeded the screening allowable and one for which the result was withheld.



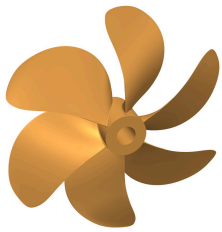
A · Bulk carrier

4 blades, 6.9 m, moderate skew



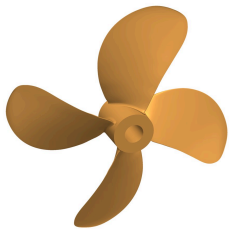
B · Gas carrier

5 blades, 8.3 m, high skew, raked



C · Container feeder

6 blades, 7.4 m, wide blades



D · Product tanker

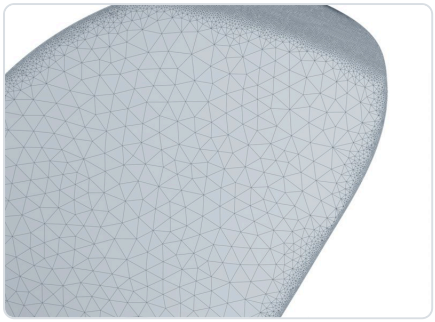
4 blades, 5.8 m, left-handed

	A	B	C	D
PARTICULARS SUPPLIED				
Diameter, m	6.90	8.30	7.40	5.80
Number of blades	4	5	6	4
Pitch ratio at 0.7R	0.839	0.849	0.976	0.830
Expanded area ratio	0.48	0.55	0.78	0.52
Skew angle, degrees	18	34	30	22
Power, kW, at shaft speed, rev/min	8,900 at 88	12,500 at 74	21,000 at 95	6,200 at 105
Ship speed, knots; wake fraction assumed	14.2; 0.34	16.5; 0.30	19.5; 0.26	14.0; 0.33
GENERATED PROPERTIES				
Casting mass, tonnes	20.8	38.8	37.2	12.8
Mass moment of inertia, shaft axis, in air, kg·m²	40,400	116,800	97,700	17,600
Thrust applied, kN (estimated)	996	1,267	1,697	693
Torque applied, kN·m	956	1,597	2,090	558
STATIC STRENGTH SCREENING (CAST NI-AL BRONZE, GRADE CU3; ALLOWABLE 65.6 MPA)				
Elements on the three meshes, thousand	106 / 174 / 360	123 / 202 / 410	199 / 337 / 491	118 / 211 / 400
Peak von Mises stress, MPa	55.8	45.8	118.5	57.3
Region of peak	root	root to 0.95R	root	root
Change in peak between the two finest meshes	0.5 %	13.5 %	2.5 %	3.0 %
Maximum displacement, mm	17.4	24.5	18.7	15.6
Peak stress / screening allowable	0.85	0.70	1.81	0.87
Screening result against allowable	Within	Withheld	Exceeds	Within
Duration of study, minutes	20	35	79	29

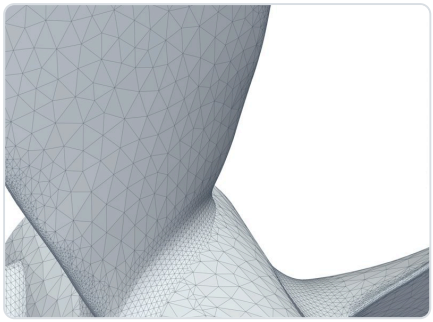
Results B and C are reported without adjustment. For B, the peak stress near 0.975R changed by 5.6 % between the two finest meshes, which exceeds the 5 % convergence criterion; the verdict was therefore withheld. For C, the solution converged and the peak stress in the root region exceeds the screening allowable; the root scantlings of that design would require revision. Neither outcome was adjusted.

Basis. The screening allowable is the specified minimum tensile strength of grade CU3, 590 MPa, divided by 9. It is adopted here as a static screening basis only: it is not a fatigue criterion and not a rule requirement for these propellers. Material properties are specified minima, not values from a heat certificate. Torque is the stated power, less 1 % shaft loss, divided by angular speed. Thrust is estimated as open-water efficiency × delivered power ÷ speed of advance, with the efficiency taken from published systematic-series data and the wake fraction as assumed above; it has not been verified against a design calculation. Stress is nodally averaged von Mises stress from a linear-elastic static analysis.

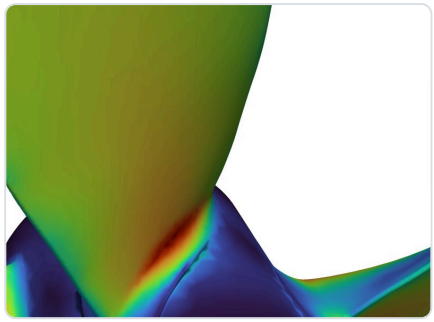
Mesh and stress detail



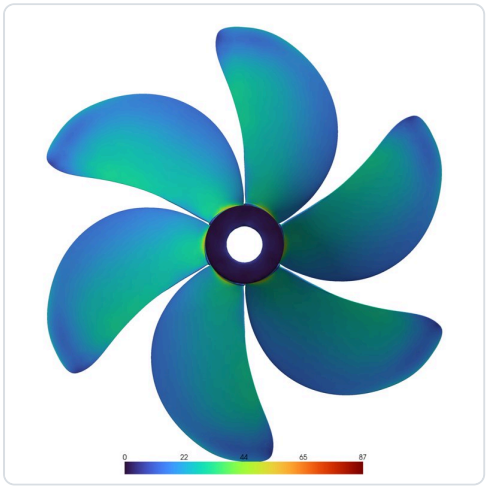
Propeller D, blade tip. Element size is reduced towards the tip and along both edges, where the section is thinnest.



Propeller A, blade root. Blade and boss form a single fused solid with the root fillet modelled; the root stress is computed on the modelled geometry.



Propeller A, von Mises stress at the root on the finest mesh. Peak 55.8 MPa; change from the preceding mesh 0.5 %.



Propeller C, von Mises stress in MPa, viewed from aft. The colour scale is limited to 87 MPa; the peak of 118.5 MPa lies in the root region.

One procedure, no manual data transfer

1 Geometry
Sections, pitch, skew and rake are derived from the particulars; thickness follows a classification-society rule formula; edge and tip forms follow those of as-built propeller drawings.

2 Solid model
Blades and tapered boss are fused into one body and written in STEP format. The tip trim and the closure of the solid are verified.

3 Mesh
Ten-node tetrahedral elements at three refinement levels, with separate size controls for root, tip and edges. Mesh volume is checked against the solid; agreement in these studies was within 0.13 %.

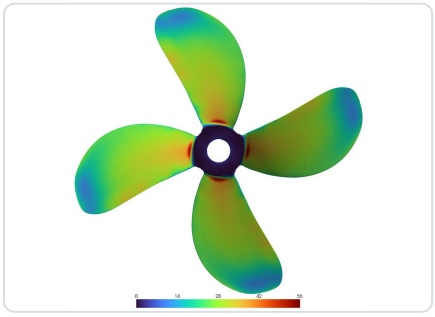
4 Solution
Linear-elastic static analysis. Total thrust, shaft torque and centrifugal load are applied with the bore fixed; force equilibrium is verified in every run.

5 Report
Stress by region and convergence between meshes are reported. The screening result is withheld where convergence is not demonstrated.

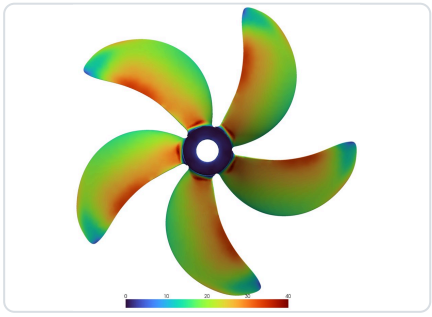
Comparison with as-built propellers

Three as-built merchant-ship propellers were regenerated from their drawing data. At the stations compared, from 0.95R to the tip, the generated maximum thickness agreed with the drawings within 0.4 %. The comparison is limited to thickness at those stations and is not a complete validation of the geometry.

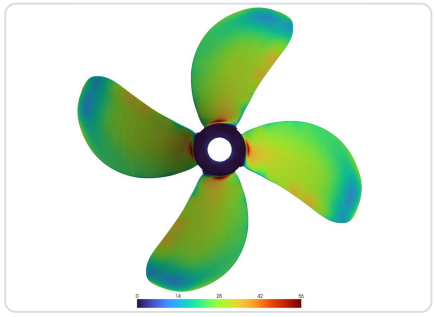
Propellers A, B and D on their finest meshes



A: peak 55.8 MPa at the root.



B: peak 45.8 MPa; result withheld.



D: peak 57.3 MPa at the root.

Scope of the beta release

Casting
The model, drawing and offsets describe the finished form, for pattern development and inspection. Casting and machining allowances, tolerances and balancing are not included.

Additive manufacturing
Generation of the three-dimensional solid model is supported. Strength computation for additively manufactured components is not implemented in this release and requires separate support.

Re-analysis
The strength screening applies to the cast condition. Meshes, input files and results are supplied in full, so that it may be repeated or extended independently.

Deliverables for each propeller

- Solid model (STEP), blades fused to the boss
- Section drawing (PDF), sections (DXF) and offset table (CSV)
- Mass, centre of gravity and mass moment of inertia, in air
- Strength screening report (PDF): material basis, loads, meshes, stress by region, convergence and limitations
- Meshes, analysis input files and result files

Criteria applied in the screening

Screening allowable, CU3 (590 MPa / 9)	65.6 MPa
Regional peak stress, two finest meshes	change ≤ 5 %
Mesh volume against solid model	within 3 %
Force equilibrium	within 1 %

Computing time measured on the four examples

Blade geometry from particulars	less than 1 second
Three-mesh study, 4 or 5 blades	20 to 35 minutes
Three-mesh study, 6 wide blades	79 minutes

One desktop workstation: Intel Core i7-13700 (24 threads), 15 GB memory. Computing time only; engineering review and reporting are additional. Times for other propellers and equipment will differ.

Covered in this release

- Fixed-pitch, open propellers in cast nickel-aluminium bronze, grade CU3.
- Linear-elastic static strength screening under total thrust, shaft torque and centrifugal load, with the bore fixed.
- Three-mesh convergence record and regional stress results for every study.

Further analyses on request

Analyses beyond those illustrated here can be undertaken with additional timelines, including:

- fatigue assessment under varying wake loads;
- loading from a hydrodynamic pressure distribution;
- other materials, and strength assessment of additively manufactured components;
- shaft and hub fit, vibration, and controllable-pitch or ducted propellers;
- casting and machining allowances for a specific foundry.

Enquiries are welcome by e-mail or through the website enquiry form.

Status of results

This is a beta release, offered for evaluation and pilot studies. Results are an engineering screening for review by a qualified engineer; they do not constitute classification-society approval. The example designs are illustrative and are not hydrodynamically optimised.

Services and third-party software

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Pilot study on a propeller of your own

Submit the particulars of a propeller for which drawings and calculations are already held. The solid model and screening report will be prepared for comparison with those records, on terms agreed in writing.

Advik Protofab Private Limited · advikprotofab@gmail.com · enquiry form at advikprotofab.com

Registered office: 1-77, Ganesh Nagar, Chinamushidiwada, Pendurthy, Visakhapatnam – 531173, Andhra Pradesh, India
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