**Propulsion of Ship (NAOE 303)**

**Part A: 2 Marks Question**

1. Define using formula and sketch wherever required : Indicated power
2. Define using formula and sketch wherever required : Break power
3. Define using formula and sketch wherever required : Shaft power
4. Define using formula and sketch wherever required : Delivered power
5. Define using formula and sketch wherever required : Thrust power
6. Define using formula and sketch wherever required : Effective power
7. Define using formula and sketch wherever required : Propulsive efficiency
8. Define using formula and sketch wherever required : Shaft efficiency
9. Define using formula and sketch wherever required : Hull efficiency
10. Define using formula and sketch wherever required : Open water efficiency
11. Define using formula and sketch wherever required : Relative rotation efficiency
12. On a sketch of a screw propeller, indicate the following: boss, blade, root, tip, face, back, leading edge and trailing edge.
13. Define and draw a sketch a diagram to indicate rake angle and skew angle.
14. Explain the terms rake and skew with reference to a propeller blade, what is skew induced rake? What is warp?
15. What is the difference between the nominal wake and the effective wake?
16. Explain momentum principle.
17. The momentum theory of propellers is said to be based on correct fundamental principles while the blade element theory is said to rest on observed facts. Explain.
18. What are the conditions that must be fulfilled in carrying out model tests with propellers?
19. What is cavitation? How is cavitation affected by the temperature and the air content of water?
20. What are the forces that are normally taken into account in calculating the stresses in a propeller blade? What are the factors that are not taken into account?
21. What are the objectives of carrying out (a) resistance experiments, (b) open water experiments and (c) self-propulsion experiments with ship models and model propellers?
22. What is the main difference between the design of propellers for merchant ships and the design of propellers for tugs and trawlers?
23. What are the tests and trials that are carried out on a ship before it is delivered to its owners?
24. What are the steps that can be taken to minimize propeller excited vibration in a ship?
25. What are the reasons for adopting unconventional propulsion devices in some ships?
26. Enumerate the different types of ships commonly used today.
27. Explain the concept of the pitch of a screw propeller. What is variable pitch?
28. Why is the propeller efficiency derived from the axial momentum theory called an "ideal efficiency"? In which condition will this efficiency be 100 percent?
29. How are the differences between the conditions of the model experiment and the operating conditions of a ship taken into account in determining the effective power of the ship?
30. What are the two approaches to propeller design? Discuss their comparative advantages.
31. Why are the speed trials of a ship carried out?
32. What are the advantages and disadvantages of using feathering paddle wheels instead of wheels with fixed paddles?
33. Discuss the development of ship propulsion machinery during the last two hundred years.
34. What are the desirable properties in a material used for making propellers?
35. Explain how an anti-singing edge eliminates the singing of a propeller.
36. In what types of ships would you consider the use of a controllable pitch propeller, and why?
37. What are the contributions made to ship propulsion by its pioneers: Colonel Stevens, Josef Ressel, Ericsson and Petit-Smith?
38. How would you obtain the expanded and developed blade outlines of a propeller from the projected outline?
39. Why can propeller cavitation not be studied by model experiments in a conventional ship model tank?
40. Why does thrust deduction occur?
41. What are the steps that a propeller designer can take to prevent propeller cavitation?
42. What are the additional 'forces and moments that occur in a propeller blade due to large skew?
43. What are the quantities that are measured in a self-propulsion test?
44. What are the factors to be considered in determining the shape of propeller blade sections and their thicknesses?
45. Ducted propellers may have either accelerating ducts or decelerating ducts. What are the reasons for choosing one type or the other?
46. What are the different types of propulsion devices used in ships?
47. Explain the concept of circulation and describe how it gives rise to lift in an aerofoil section.
48. Why is the relative rotative efficiency not equal to 1 in general?
49. How is the cavitation of a propeller blade section affected by the shape of its mean line, the camber ratio, the thickness ratio and the angle of attack?
50. How do the blade sections of a supercavitating propeller differ from those of a conventional propeller?
51. What is the effect of surface roughness on the performance of a propeller?
52. Describe the vortex system of a wing of finite span. How is this vortex system related to the vortex system of a propeller blade'?
53. Why are Bp-δ diagrams more convenient to use in propeller design than KT- KQ diagrams?
54. What are the dimensional parameters whose values must be carefully controlled in manufacturing a propeller?
55. Why are contra-rotating propellers more efficient than single propellers for the same thrust?
56. What are the advantages and disadvantages of designing a tug propeller for (a) the bollard pull condition and (b) the free running condition?
57. What are the major non-dimensional parameters used to describe a screw propeller?
58. Discuss the condition in which a propeller has the highest efficiency for a given speed of advance and revolution rate.
59. Why can Bp-δ diagrams not be used for designing tug propellers? What type of diagrams is specially meant for designing tug propellers?
60. What do you understand by the effective power of a ship? Describe the stages by which the power produced by the main engine of the ship is transformed into the effective power.
61. Discuss the relation between the maximum rated output of the propulsion plant and the power for which the propeller is designed.
62. Outline the principal steps in designing a propeller using the lifting line theory.
63. Explain the concepts of "service margin" and "engine margin" on the power of a ship propulsion plant, on what factors do these margins depend?
64. Explain the action of a Voith Schneider propeller, and show with the help of a sketch how it may be used to stop a ship moving ahead.
65. Describe the recent developments in propeller theory.

**Part B: 4 Marks Question**

1. Define for skew propeller with proper diagram: Face, Back, leading edge and trailing edge, Geometric pitch, Pitch, Mean line or camber, Blade thickness
2. Define rake angle and skew angle. Write the advantages and disadvantages.
3. Criteria for deciding propeller blade section.
4. Explain types of ship engines .
5. Describe the different types of cavitation and the conditions under which they occur.
6. Explain CL VS α curve for symmetrical and cambered airfoil with proper diagram.
7. Explain axial momentum theory. Derive the formula for ideal efficiency.
8. Difference between axial, impulse and blade element theory.
9. Explain assumption made for axial, impulse and blade element theory.
10. Draw velocity triangle for blade element theory.
11. Explain the variation of rate of thrust and torque along blade length from root to tip with neat sketch.2
12. Explain blade circulation theory.
13. Explain the purpose of dimensional analysis in ship propulsion.
14. Explain types of mechanical similarity.
15. Which scaling law has been used for converting the properties from model to prototype and vice versa?
16. Explain Froude similarity and Cavitation similarity and Reynolds similarity.
17. Explain cavitation tunnel test with diagram.
18. Explain the p+urpose of open water test.
19. Explain open water test performed in towing tank, draw open water diagram (KT ,KQ, η vs J)
20. Explain how the hull and the propeller of a ship interact with each other.
21. Explain: Potential wake, Frictional wake, Wave wake, Nominal wake, Effective wake.
22. Explain thrust deduction factor with the help of diagram.
23. Explain cavitation and how to prevent the cavitation.
24. What is cavitation number and its importance.
25. Explain Self-propulsion test with proper diagram: Constant speed method (British method)
26. Explain Self-propulsion test with proper diagram: Constant load method (Continental method)
27. Explain Self-propulsion test with proper diagram: Mixed loading method
28. Define wake fraction. Explain Froude wake factor and Taylor wake factor.
29. What is wake fraction? What is positive wake and negative wake?
30. Define the components of wake fraction.
31. Explain with diagram face cavitation
32. Explain with diagram tip vortex cavitation.
33. Explain with diagram sheet cavitation.
34. Explain with diagram cloud cavitation.
35. Explain with diagram bubble cavitation.
36. Explain with diagram Super cavitation.
37. Effect of cavitation on propeller blade.
38. Explain unconventional propulsion system: Fixed paddle wheel
39. Explain unconventional propulsion system: Feathering paddle wheel
40. Explain unconventional propulsion system: controllable pitch propeller(CPP)
41. Explain unconventional propulsion system: Nozzle propeller
42. Explain unconventional propulsion system: Bollard pull propeller
43. Explain unconventional propulsion system: Ducted/Kort nozzle propeller (i) Accelerating (ii) Decelerating nozzles
44. Explain unconventional propulsion system: Schottel rudder propeller (SRP)
45. Supercavitataing propeller.
46. Why use hybrid conrarotataing propulsion system.
47. Write a note on Tandom propellers with proper diagram.
48. Explain podded propellers with merits and demerits.
49. Write a note on cycloidal propeller.
50. Write a note on kirston boeing propeller.
51. Write a note on Voith Schneider propeller.
52. Write down a note on bow thruster. What is use of bow thruster?
53. Derive the formula for bending moment due to thrust and torque.
54. Derive the formula for bending moment due to centrifugal forces.
55. What are the parameters considered for deciding blade material.
56. Why is it not possible to make the Reynolds numbers of a ship propeller and its model equal and simultaneously make the two Froude numbers equal too? Why are the Froude numbers made equal rather than the Reynolds numbers?
57. The wake of a ship has three component causes, which of these components would be absent if: (a) the ship was moving in an inviscid fluid, (b) the ship had an infinitesimal breadth, and (c) the ship was moving deeply submerged? Can you think of a situation in which the wake fraction would be zero at all speeds?
58. How are the stresses in a propeller blade affected by (a) the mass of the blade, (b) the propeller rpm, (c) the rake of the blade and (d) its skew, the thrust and torque being fixed?
59. In the axial momentum theory, the pressure in the slipstream far astern of the propeller is equal to the pressure far ahead, Will this be true if the rotation of the slipstream is taken into account?
60. Why is it important to obtain turbulent flow in model experiments with, ship models and model propellers? What steps are taken to ensure turbulent flow?
61. What are the considerations in selecting (a) the number of propellers in a ship, (b) the number of blades in a propeller, (c) the propeller diameter, (d) the rake of the propeller blades, and (d) the propeller blade skew?
62. Sketch the velocity and force diagrams of a propeller blade section (a) neglecting induced velocities and section drag, (b) including induced velocities but neglecting drag, and (c) including both induced velocities and drag.
63. What is a methodical propeller series? What are the parameters that are varied in a typical methodical series?
64. Explain the concept of "ship self-propulsion point on the model". Why is a ship model not generally fully self-propelled in a self-propulsion experiment?
65. Distinguish between nominal slip, apparent slip and effective slip. How is effective slip related to the effective pitch of a propeller?
66. What are the components of the propulsive efficiency of a ship? How would these components be affected if the propeller were placed in front of the ship rather than behind it?
67. What are the geometrical parameters upon which the mass and polar moment of inertia of a screw propeller depends? If in two geometrically similar propellers one has a diameter twice that of the other, what will be the ratios of their masses and polar moments of inertia?

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**Part C: 14 Marks Questions**

1. Explain axial momentum theory. Derive the formula for ideal efficiency.
2. Explain impulse momentum theory. Derive the formula for ideal efficiency.
3. Explain blade element theory. Derive the formula for ideal efficiency.
4. Explain how cavitation affects the performance of propeller. Describe the types of cavitation.
5. What is the purpose of open water test? Its types. Briefly explain with the help proper diagram.
6. Explain the types of unconventional propulsion system with the help of proper diagram.
7. What is supercavitating propeller? When it will work efficiently? What is the problems related to it.
8. Explain contrarotating and Hybrid contrarotating propeller with its advantages and disadvantages.
9. Write a note on cycloidal propeller showing its proper arrangemet. Types of cycloidal propeller.
10. Explain water jet propulsion with its proper arrangement. Write down its advantages and disadvantages.
11. Explain with diagram, which are the parameters considered for propeller design?
12. Effect of propeller diameter, RPM, Number of blades, radial distribution of loading, blade outline, Camber and angle of attack and skew angle.
13. What are the assumptions made to find out the strength of propeller blade?
14. A propeller of 2m diameter produces a thrust of 30 KN when advancing at a speed of 4 m/s in sea water. Determine the power delivered to propeller, the velocities in slip stream at the propeller disc and at a section far astern, the thrust loading coefficient and the ideal efficiency.
15. A propeller of 3 m diameter absorbs 700 KW in the static condition in sea water. What is its thrust?
16. A propeller of diameter 4 m has an rpm of 180 when advancing into sea water at a speed of 6 m/s. The element of the propeller at 0.7R produces a thrust of 200KN/m. Determine the torque, the axial and rotational inflow factors, and efficiency of the element.
17. A four bladed propeller of 3 m diameter and 1 constant pitch ratio has a speed of advance of 4 m/s when running at 120 rpm. The blade section at 0.7R has a chord of 0.5m, a non-lift angle of 2 degrees, a lift-drag ratio of 30 and lift coefficient that that increases at the rate of 6 per radian for small angles of attack. Determine the thrust, torque, and efficiency of the blade element at 0.7R
18. Neglecting the induced velocities and (b) given that the axial and rotational inflow factors are 0.2 and 0.0225 respectively.
19. A propeller running at a revolution rate of 120rpm is found to produce no thrust when its velocity of advance is 11.7 knots and to work most efficiently when its velocity of advance is 10 knots. What is the effective pitch of the propeller and the effective slip ratio at which the propeller is most efficient?
20. In a four bladed propeller of 5 m diameter, the expanded blade widhs at the different radii are as follows:

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| r/R | 0.2 | 0.3 | 0.4 | 0.5 | 0.6 | 0.7 | 0.8 | 0.9 | 1.0 |
| C mm | 1454 | 1647 | 1794 | 1883 | 1914 | 1876 | 1724 | 1384 | 0 |

The thickness of the blade at the tip is 15mm and at r/R = 0.25, it is 191.25mm. the propeller boss is shaped like the frustum of cone with a length of 900mm,and has forward and aft diameters of 890mm and 800mm. The propeller has a rake of 15 degrees aft and the reference line interests the axis at the mid-length of the boss. Determine the expanded blade area ratio, the blade thickness fraction and the boss diameter ratio of the propeller.(14)

1. A ship propeller of 5.76m diameter 0.8 pitch ratio, 0.55 blade area ratio, 0.05 blade thickness fraction and 0.18 boss diameter ratio produces a thrust of 12000KN with a delivered power of 15000KW at 150rpm and 7.5m/s speed of advance in sea water. The depth of immersion of the propeller is 6.0m. A 0.16m diameter model of this propeller is tested in fresh water. Determine for model propeller (a) pitch, (b) blade area, (c) blade thickness at the shaft (d) boss diameter (e) speed of advance (f) revolution rate (g) thrust (h) delivered power and (i) total pressure if the Froude numbers of the model and the ship propeller are to be made equal. What is the ratio of the Reynolds number of the ship and propeller to the Reynolds number of model propeller?(14)
2. The open water characteristics of the propeller of 0.8 pitch ratio are as follows:

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| J | 0 | 0.2000 | 0.4000 | 0.6000 | 0.8000 |
| KT | 0.3400 | 0.2870 | 0.2182 | 0.1336 | 0.0332 |
| 10KQ | 0.4000 | 0.3568 | 0.2905 | 0.2010 | 0.0883 |

If these results are obtained by running a model propeller of 0.2m diameter at 3000rpm over a range of speeds in fresh water, determine (a) the power of the motor required to drive the propeller (neglecting losses) (b) the maximum thrust, (c) the maximum open water efficiency (d) the speed at which maximum efficiency occurs (e) the speed at which the propeller has zero thrust and (f) the effective pitch factor, i.e the ratio of the effective pitch to the face pitch of the propeller.(14)

1. A propeller of 3.0m diameter and pitch ratio runs at 150rpm at zero speed of advance. If the engine driving the propeller produces a constant torque. Find the propeller rpm, delivered power and thrust at the following speeds of advance:0, 3, 6, 9 and 12 knots. Use the µ-σ diagram.
2. A ship has a speed of 20.0 knots when its propeller of 5.0 m diameter has an rpm of 150 and produces a thrust of 500 KN at a delivered power of 5650 KW. The resistance of the ship at 20.0 knots is 390 KN, and the open water characteristics of the propeller are as follows:

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| J | 0.500 | 0.550 | 0.600 | 0.650 | 0.700 |
| KT | 0.174 | 0.154 | 0.133 | 0.110 | 0.085 |
| 10KQ | 0.247 | 0.225 | 0.198 | 0.173 | 0.147 |

Using (a) thrust identity and (b) torque identity, determine the wake fraction, the thrust deduction fraction, the relative rotative efficiency and the open water efficiency.

1. A ship has a speed of 18.0 knots when its engine has a brake power of 10000 KW at 150rpm. The engine is directly connected to the propeller which has a diameter of 6.0 m. The effective power of ship is 6700 Kw and the propeller produces a thrust of 900 KN. The open water characteristics of the propeller are given by:

KT = 0.319 – 0.527 J + 0.169 J2

10KQ = 0.354 – 0.578 J + 0.203 J2

Determine the propulsive efficiency and their component based on the thrust identity. The shafting efficiency is 0.970.

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Determine the propulsive efficiency and their component based on the torque identity. The shafting efficiency is 0.970.

1. A propeller blade section begins to cavitate when its relative velocity with respect to undistributed water is 32 m/s and its depth below the surface of water is 4.0 m. Determine the velocity of water with respect to the blade at the point where cavitation occurs, assuming that cavitation occurs when the local pressure falls to the vapour pressure.
2. A propeller of 6.0 m diameter has a speed of advance 8.0 m/s and an rpm of 108, its axis being 5.0m below the surface of water. Calculate cavitation number
3. Based on pressure at shaft axis and the speed of advance
4. Based on blade tip speed.
5. Based on resultant velocity at the blade tip
6. Based in the resultant velocity at 0.7R.
7. Based on the pressure and relative velocity at 0.8R.
8. A propeller of diameter 5.5 m and pitch ratio 1 has its axis 4 m below the water surface. The propeller has a speed of advance of 7 m/s when running at 120 rpm and produces a thrust of 520 KN. Determine the expanded blade area ratio of the propeller using the Burrill criteria for merchant ship propellers.



1. A twin screw high speed ship with a transom stern has three bladed propellers of 3.0 m diameter, the propeller axis being 3.5 m below the water surface. The ship has a speed of 30 knots at which its effective power is 10000 KW and the thrust deduction fraction is 0.06. Determine the expanded blade area ratio using the Keller criterion.
2. A three bladed propeller of 3.0 m diameter has a thrust of 360KN and a torque of 300KN m. Determine the bending moments due to thrust and torque in the root section at 0.3 m radius, assuming that the thrust and torque are uniformly distributed between this radius and the propeller blade tip.
3. A three bladed propeller of 3.0 m diameter has a thrust of 360KN and a torque of 300KN m at 180rpm.The thrust and torque may be assumed to be linearly distributed:

 

Between the root section at x = 0.2 and x = 1.0. Determine the bending moments due to thrust and torque at the root section. How do these values compare with the values obtained by using the distributions of below equation :

 

1. The areas of blade sections at various radii of a propeller of 3.0 m diameter are as follows

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| r/R | 0.2 | 0.3 | 0.4 | 0.5 | 0.6 | 0.7 | 0.8 | 0.9 | 1.0 |
| Area, m2 | 0.0651 | 0.0802 | 0.0843 | 0.0807 | 0.0691 | 0.0538 | 0.0358 | 0.0168 | 0 |

The propeller runs at 180 rpm. The propeller is made of Manganese Bronze with a density of 8300 kg per m3. Determine the centrifugal force on the blade if the root section is at 0.2R. If the centroid of the section is at distances of 0.0150 m and 0.035 m from the line of action of the centrifugal force measured parallel and perpendicular to the propeller axis, determine the bending moments due to rake and skew.

1. A ship of length 100 m and wetted surface of 2700 m2 has a speed of 15 knots. A 4.0 m long geometrically similarly model of the ship has a total resistance of 25.0 N at the corresponding speed. Determine the total resistance of the ship assuming a forma factor of 1.05.
2. A ship has a propeller of 4.0 m diameter with its centre line 3,0m below the surface of water. The propeller in its design condition has a speed of advance of 8.0m per sec at 150 rpm and 2500 kW delivered power, Experiments are to be carried out with a 1/16 scale model propeller in a cavitation tunnel in which the maximum speed of water in the working section is 10,0m per sec, the maximum propeller rpm is 3000, the maximum torque is 45 N in and the minimum static pressure at the centre line of the working section is 15 kN per m2. Determine the speed of water, the model propeller rpm and the static pressure at the propeller position if the model propeller is to be run (a) at the correct Froude number, and (b) just within the limits of the cavitation tunnel. The tunnel water is deaerated and the tunnel cavitation number must be reduced by 15 percent compared to the ship. What is the minimum cavitation number of the tunnel based on the speed of water in the working section?
3. The effective power of a single screw ship of length 100m at a speed of 15 knots is 2150kW. The resistance of a 4.0m long model with appendages is 25.4N at the correeponding speed. Determine the tow force to be applied to the model in a self propulsion test at this speed to obtain the ship self-propulsion point. The model propeller of diameter 0.2 m is found to run at 534 rpm for this tow force to be obtained, and the propeller thrust and torque are then 21.75 N and 0.682N m. The open water data of the model propeller are:

|  |  |  |  |
| --- | --- | --- | --- |
| J | 0.600 | 0.700 | 0.800 |
| KT | 0.199 | 0.144 | 0.088 |
| 10KQ | 0.311 | 0.249 | 0.186 |

Analyse these data and determine the rpm of the ship propeller and the delivered power given that the correlation factorsr6 i rpm ind delivered power are respectively 1.02 and 1,00.

1. In an open water experiment with a model propeller of 200mm diameter, a thrust of 252 N and a torque of 9.250 Nm are measured with the propeller running at 2400 rpm at a speed of advance of 5.6m per sec. The idle thrust and torque (to be subtracted from the measured values) are -4.0 N and 0.034 N m respectively. Determine the thrust, torque and advance coefficients. of the model propeller and its open water efficiency. The ship propeller has four blades, a diameter of 5.0 m and a constant pitch ratio of 0.8. The blade section at 0.768 has a thickness of 0.0675m and a chord of 1.375 m. If the roughness of the propeller blade surface is 30 microns, determine the thrust and torque coefficients of the ship propeller and its open water efficiency.