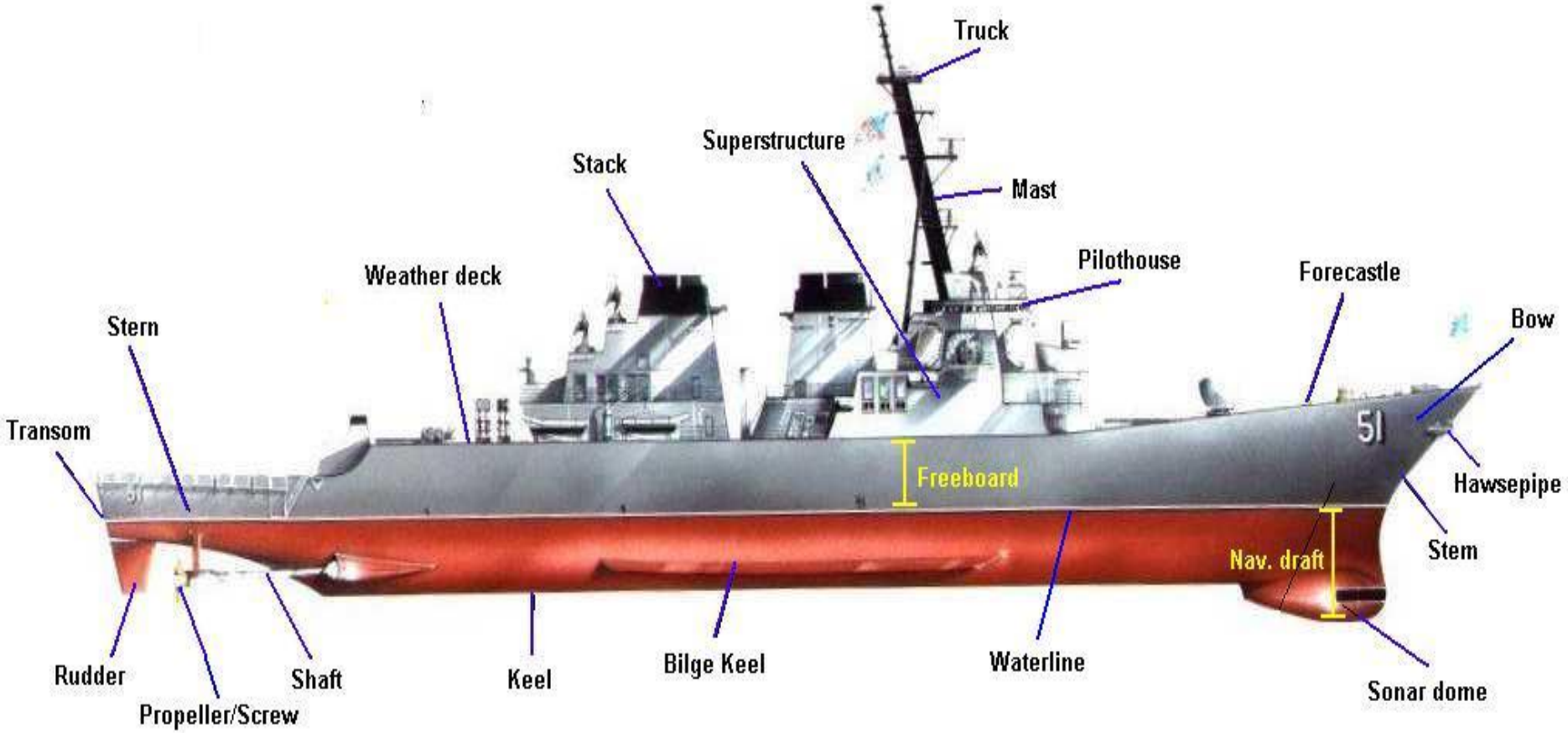
ОСНОВНЫЕ ХАРАКТЕРИСТИКИ ГРЕБНЫХ ВИНТОВ

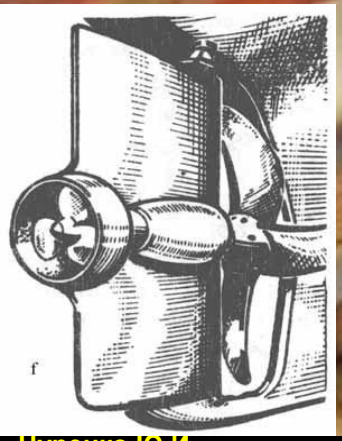
Корабельная терминология

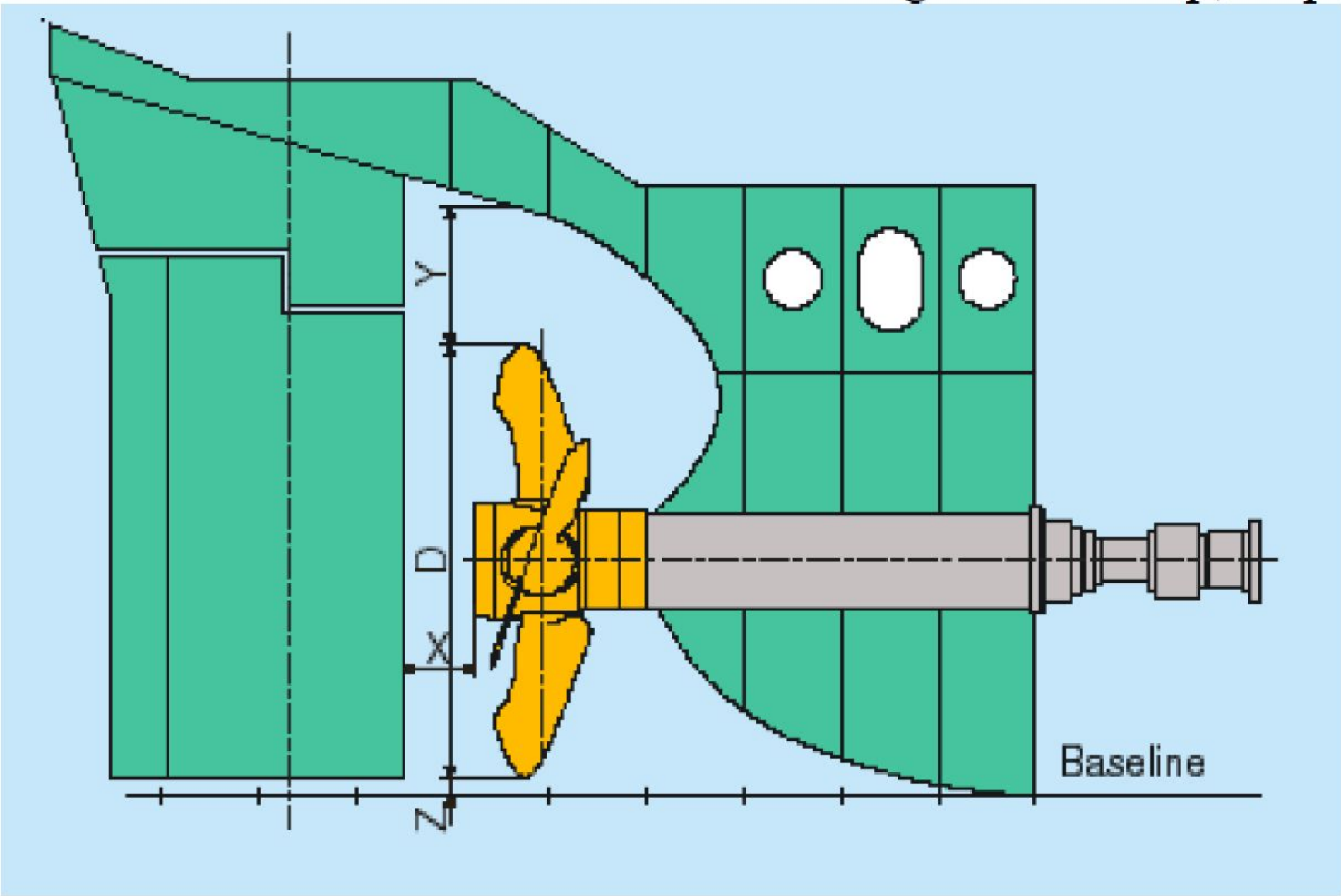


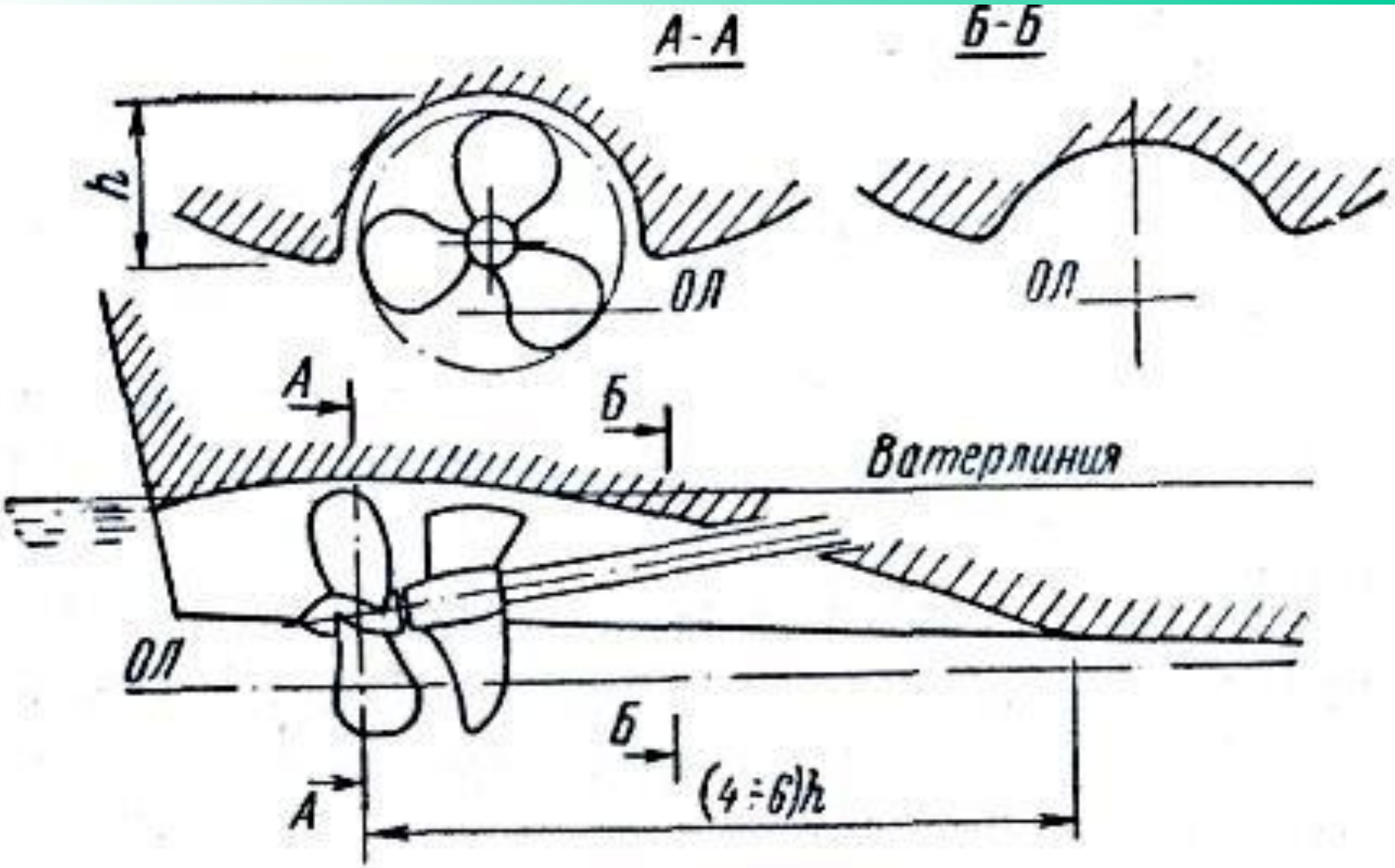
Размещение гребных винтов

Stern post with shafting of a controllable pitch propeller

Пропульсивная наделка на руле

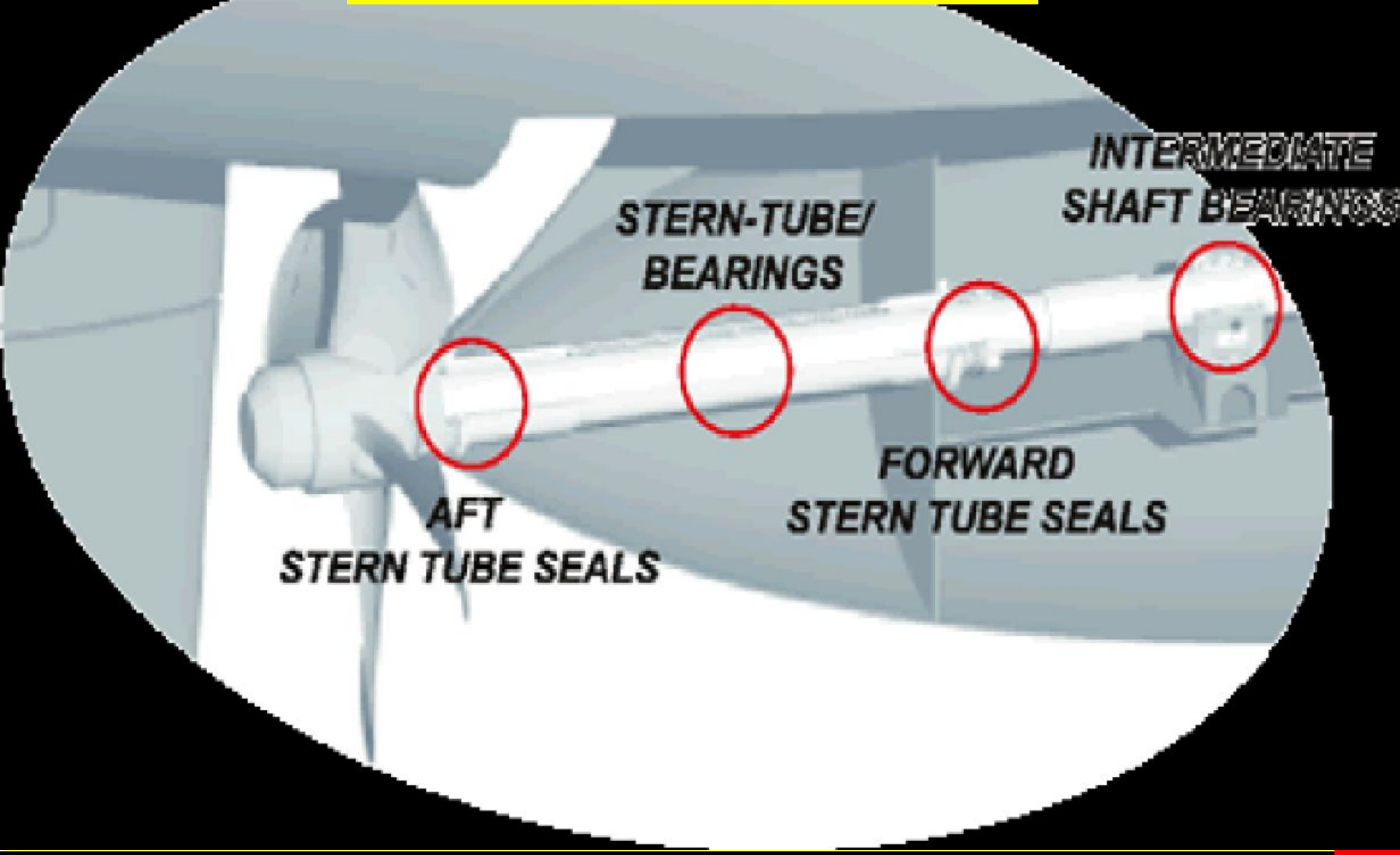



Y
D
X
Z
Baseline

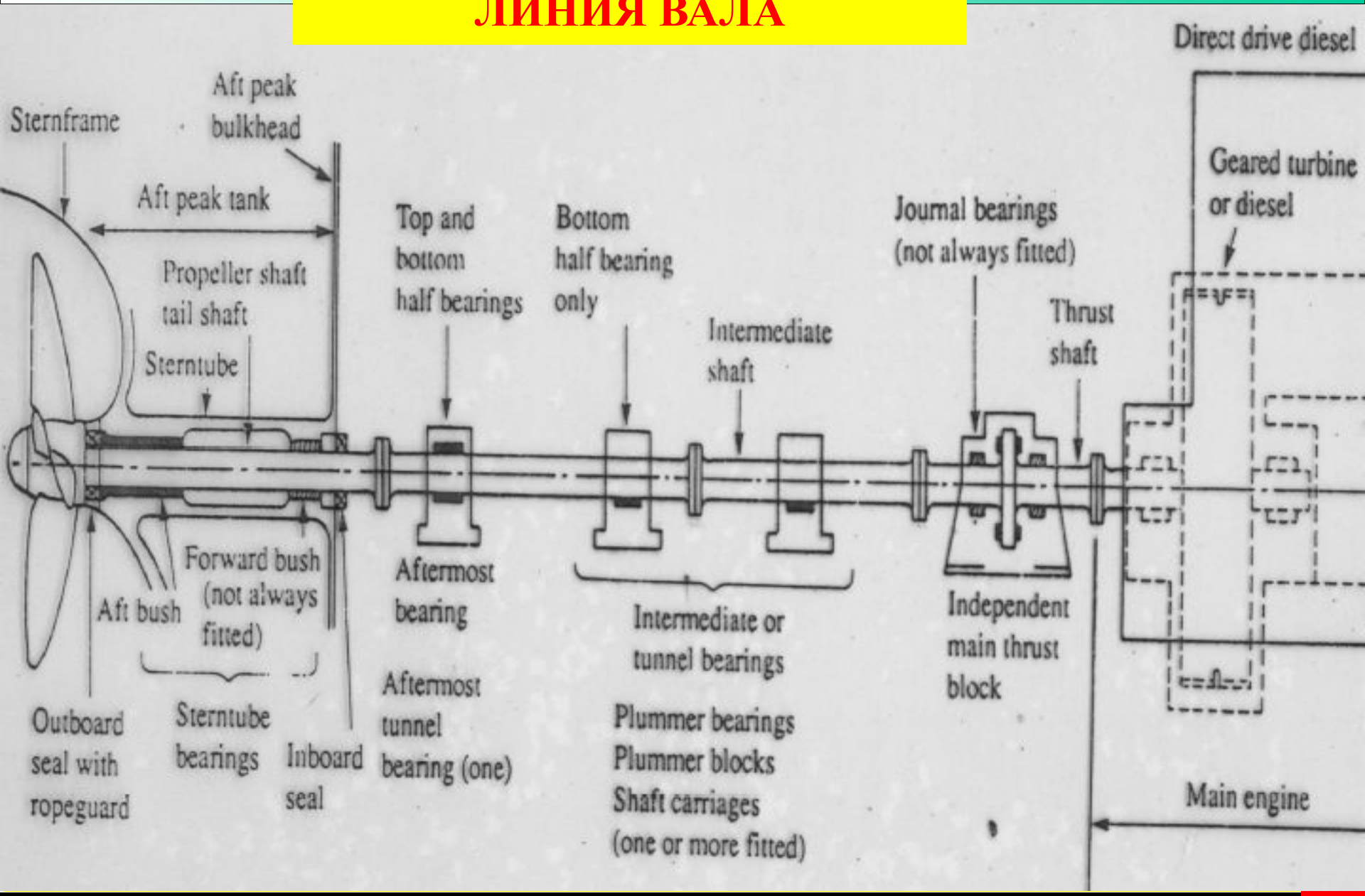


Гребной винт в туннеле.

ДЕЙДВУД

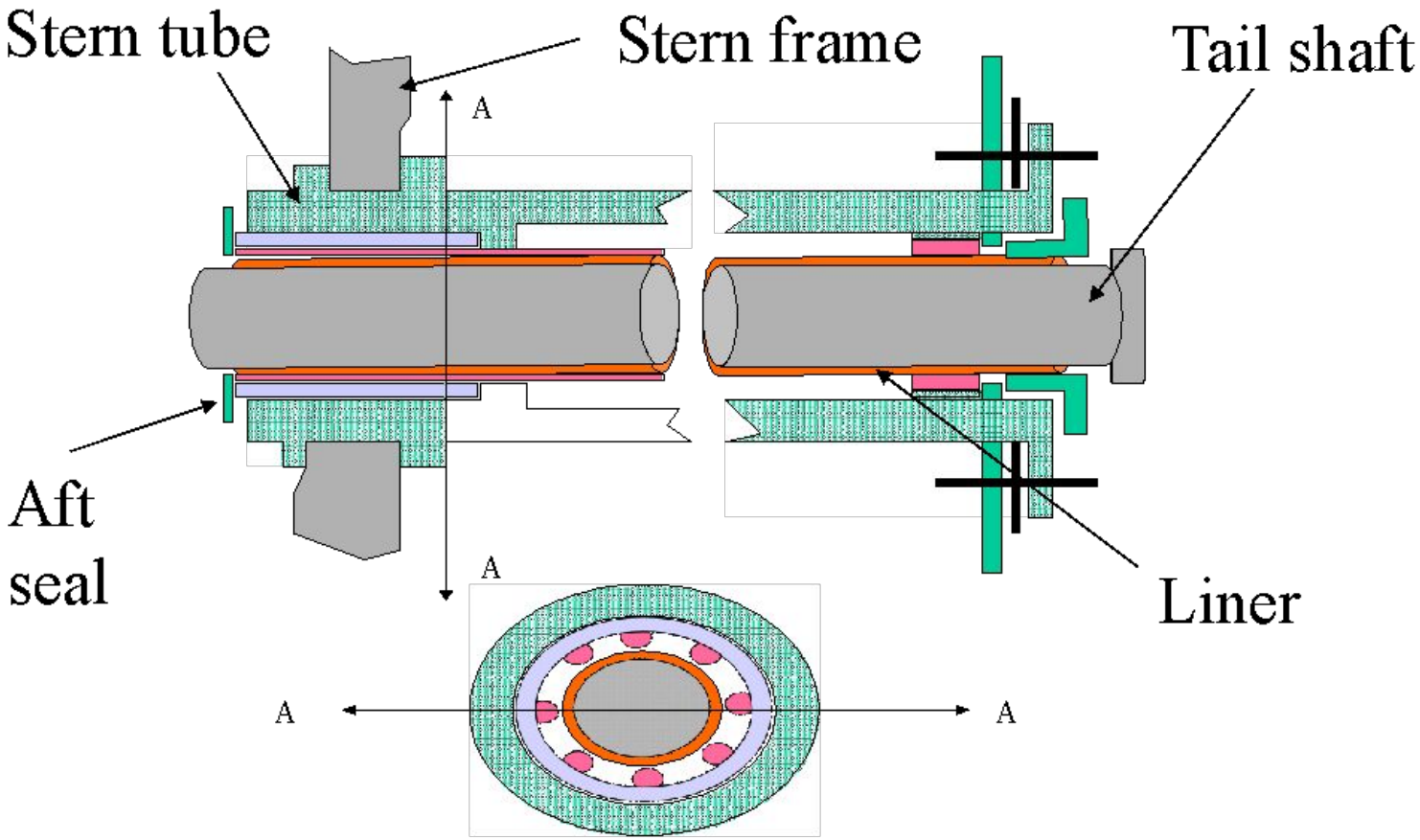

INTERMEDIATE
SHAFT BEARINGS
STERN-TUBE/
BEARINGS
FORWARD
STERN TUBE SEALS
AFT
STERN TUBE SEALS

ЛИНИЯ ВАЛА


Direct drive diesel
Sternframe
Aft peak bulkhead
Aft peak tank
Propeller shaft tail shaft
Sterntube
Top and bottom half bearings
Bottom half bearing only
Intermediate shaft
Journal bearings (not always fitted)
Thrust shaft
Geared turbine or diesel
Forward bush (not always fitted)
Aft bush
Aftermost bearing
Intermediate or tunnel bearings
Independent main thrust block
Outboard seal with ropeguard
Sterntube bearings
Inboard seal
Aftermost tunnel bearing (one)
Plummer bearings
Plummer blocks
Shaft carriages (one or more fitted)
Main engine

Water lubricated stern tube

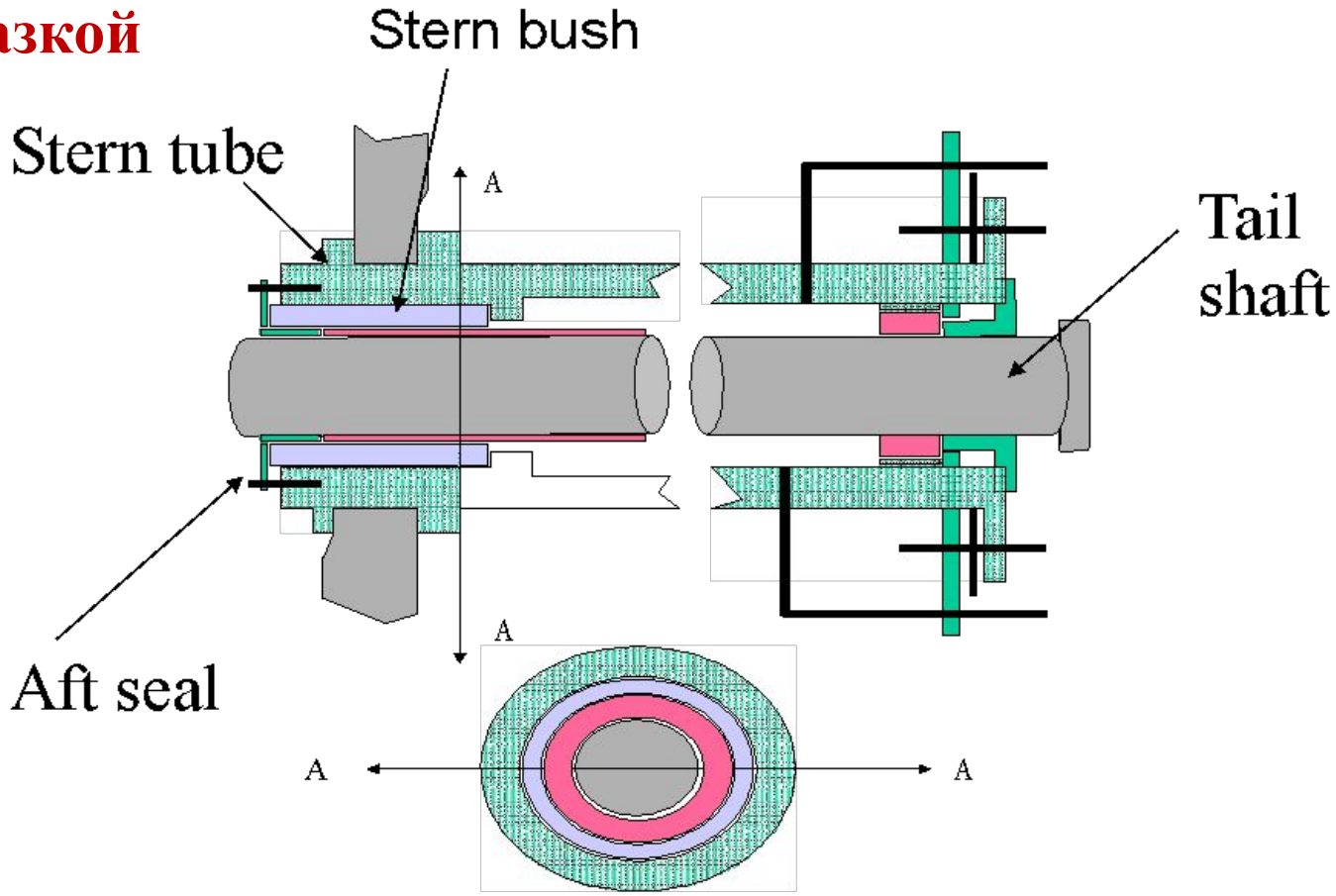
Дейдвудный подшипник с водяной смазкой



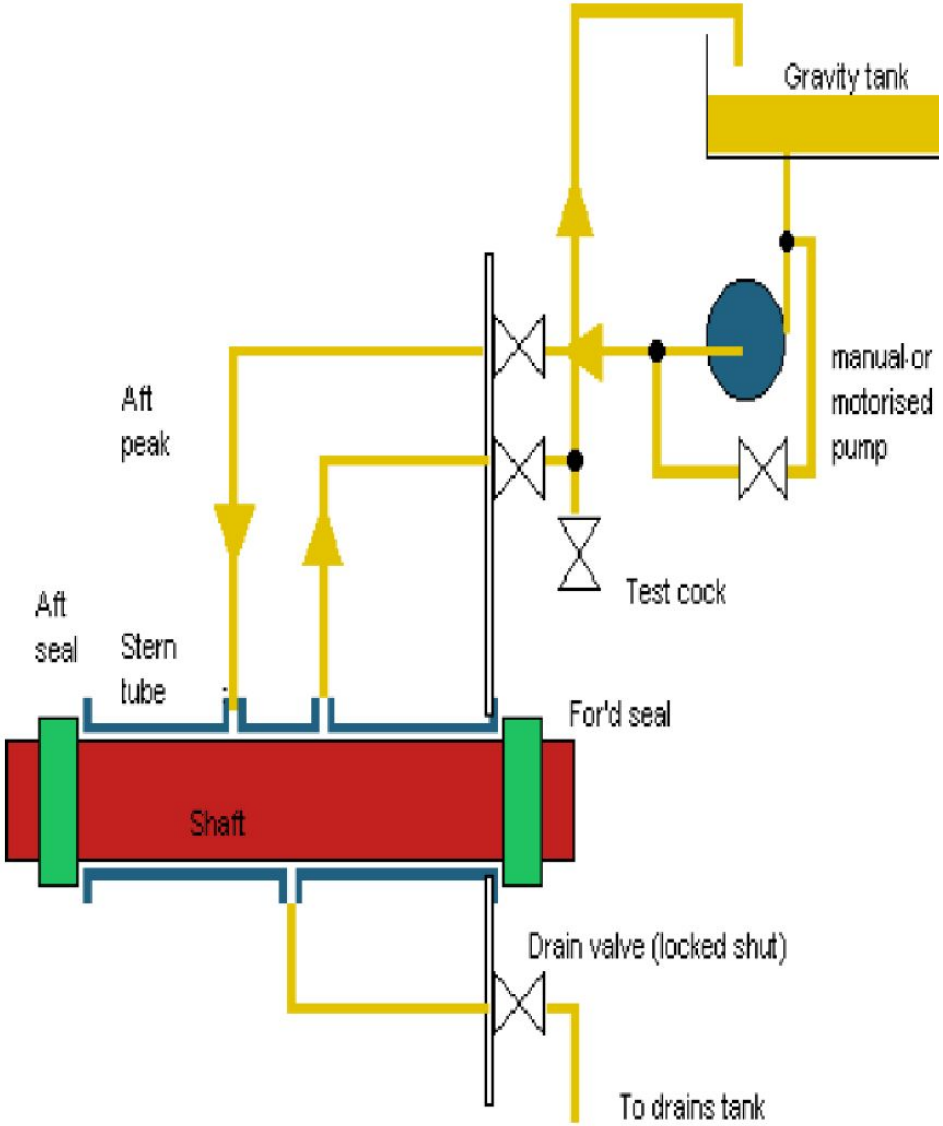
Water Cooled Sterntube

Oil lubricated stern tube

Дейдвудный подшипник с масляной смазкой



Oil Lubricated Sterntube



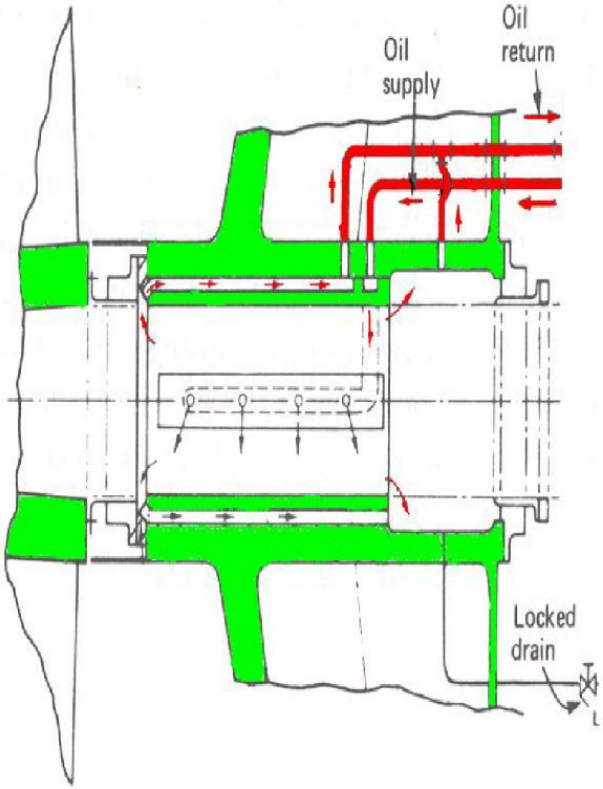
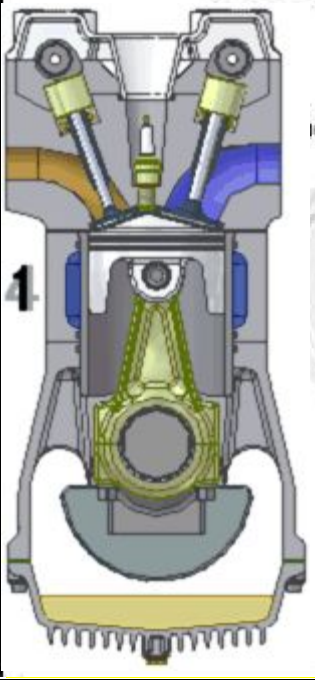
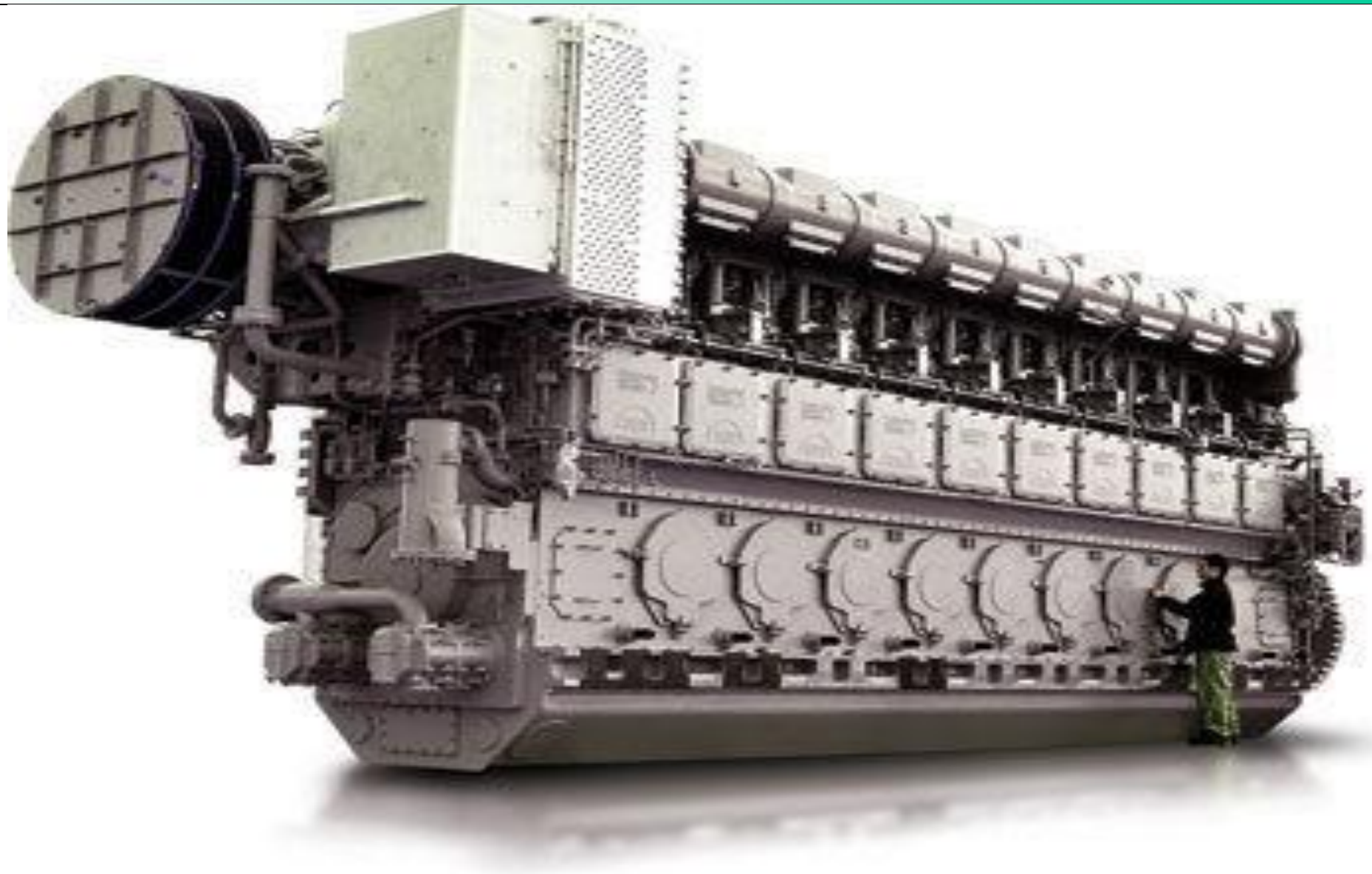


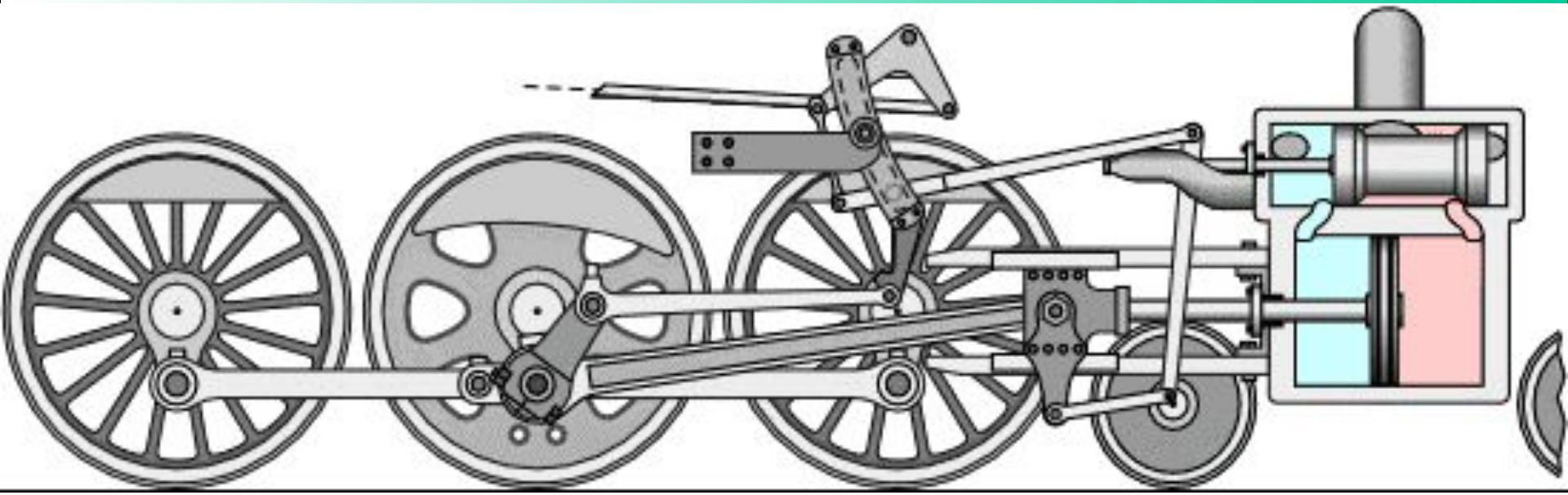
Figure 11.4 Oil lubricated sterntube bearing

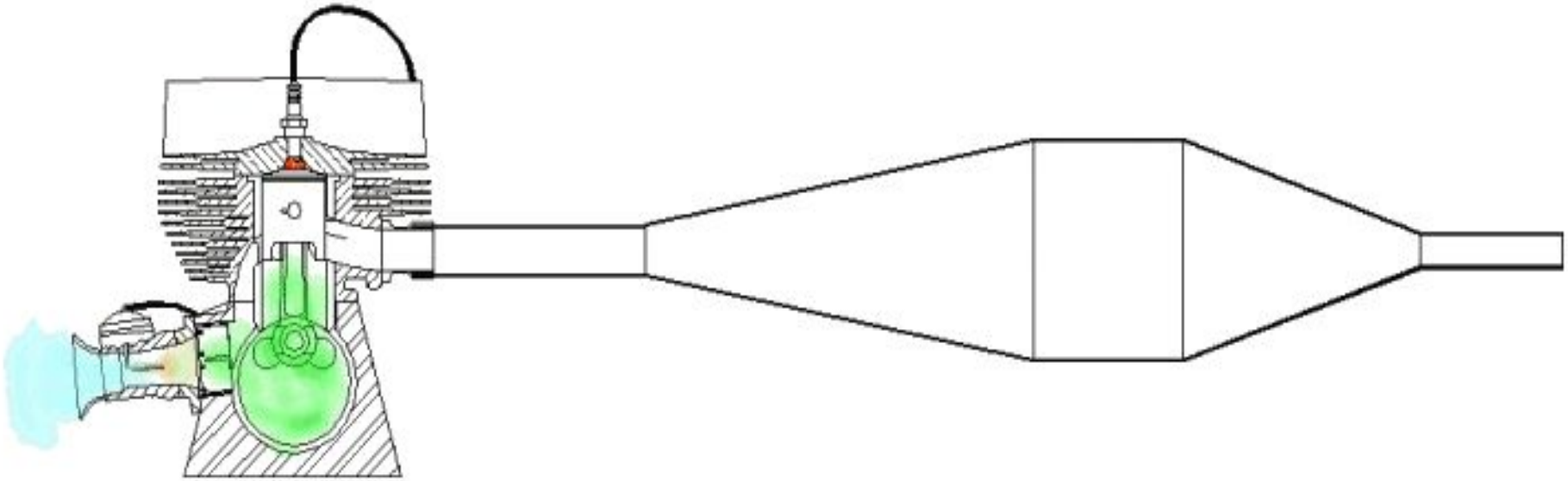
Судовой дизель

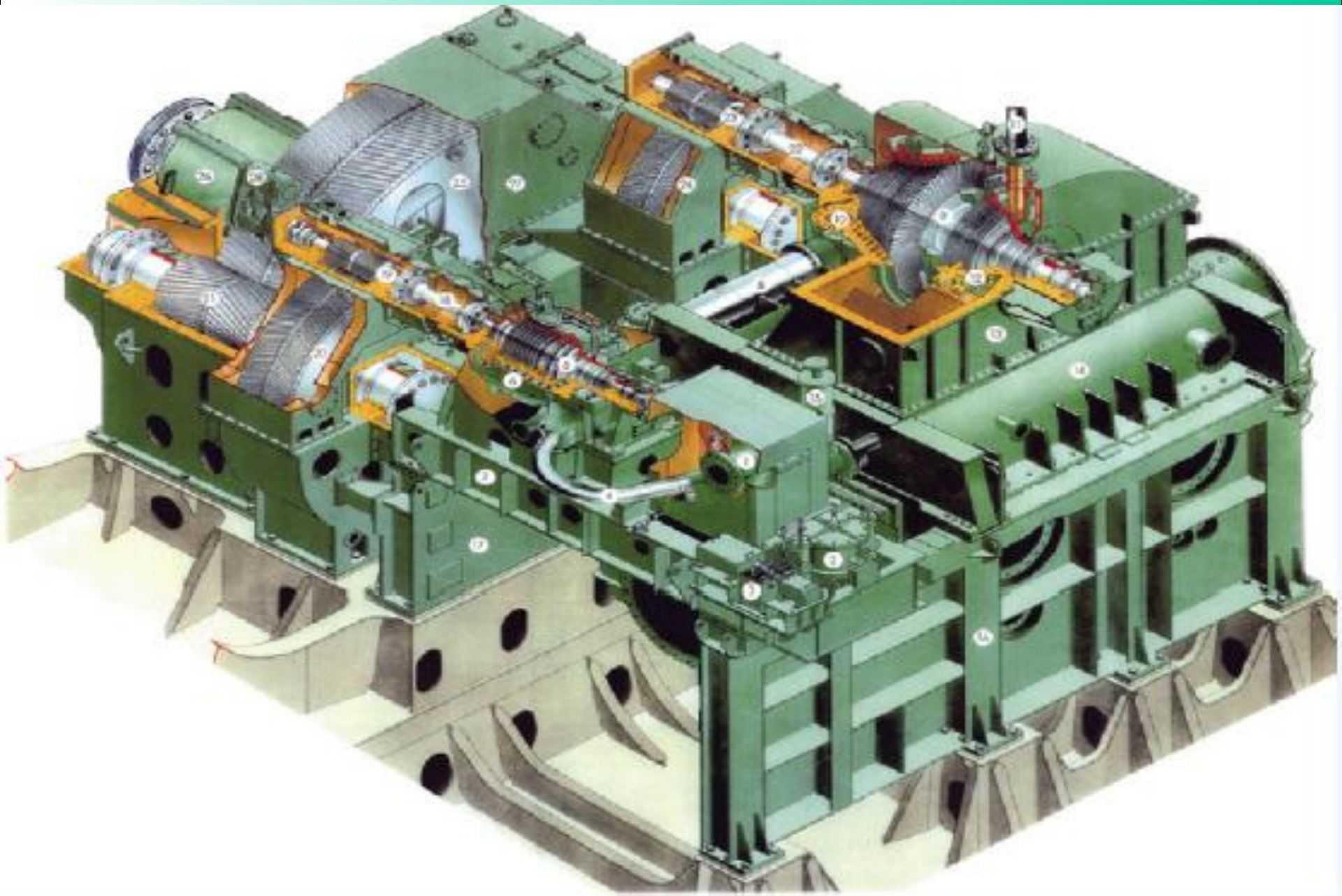


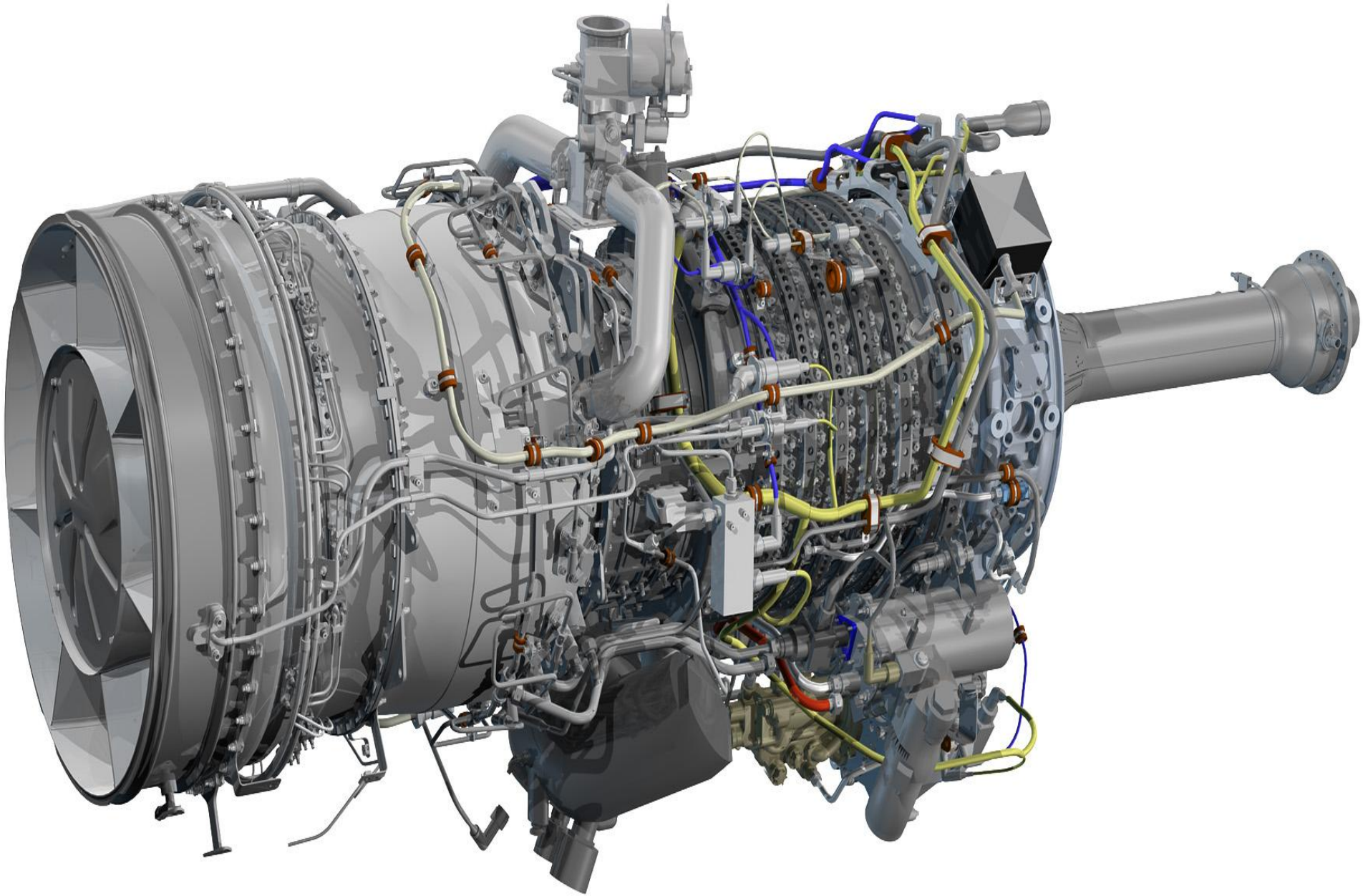
Spark plug
Intake cam
Exhaust cam
Exhaust valve
Intake valve
Clutch
Piston
Gearbox
Flywheel
Crank









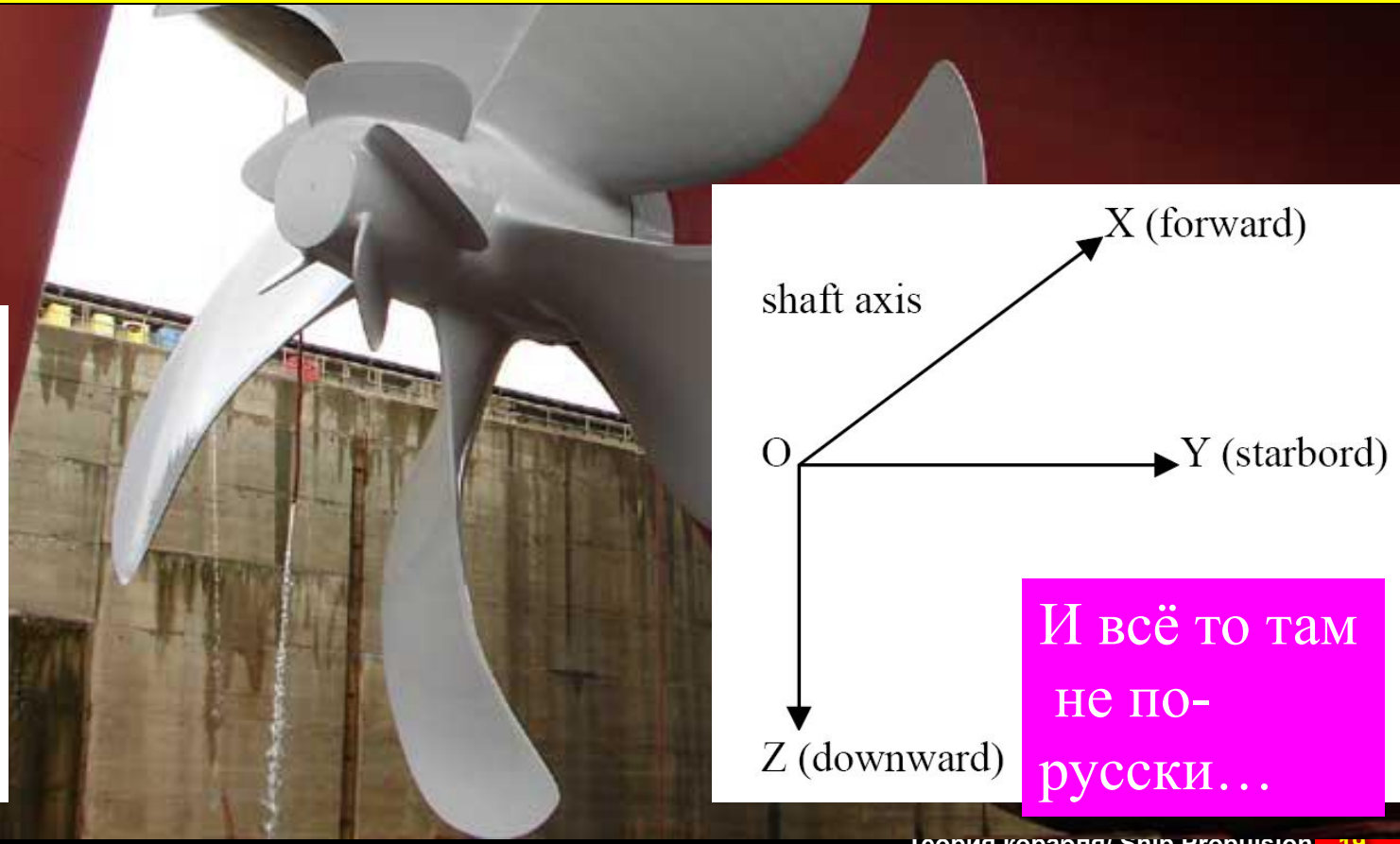


PROPELLER GEOMETRY

ГЕОМЕТРИЯ ГРЕБНОГО ВИНТА

Dictionary of Ship Hydrodynamics

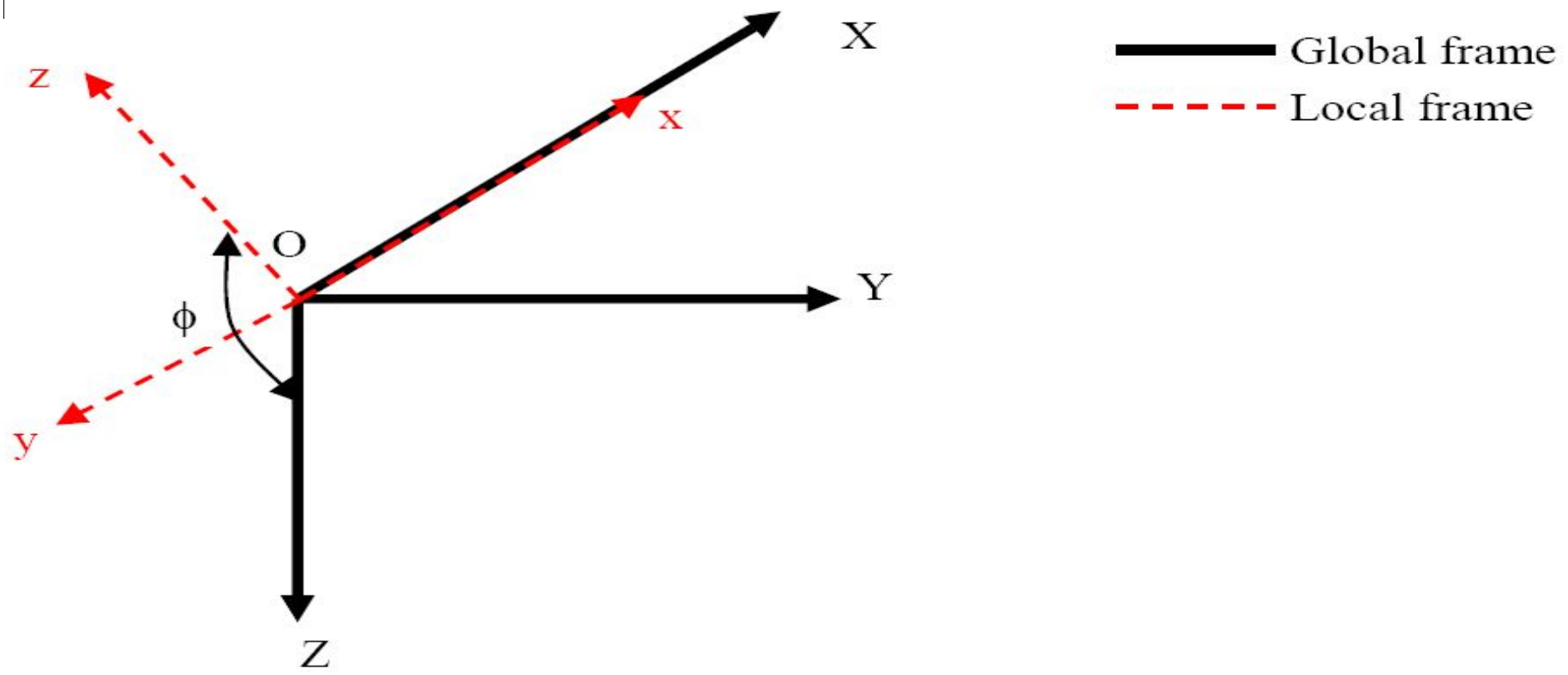
- **10th International Towing Tank Committee (ITTC) инициировала подготовку словаря терминов и обозначений корабельной гидромеханики, работа над которым продолжается с 1975 года по сей день.**
- В качестве основной(глобальной) в ITTC принята правосторонняя декартова система координат.



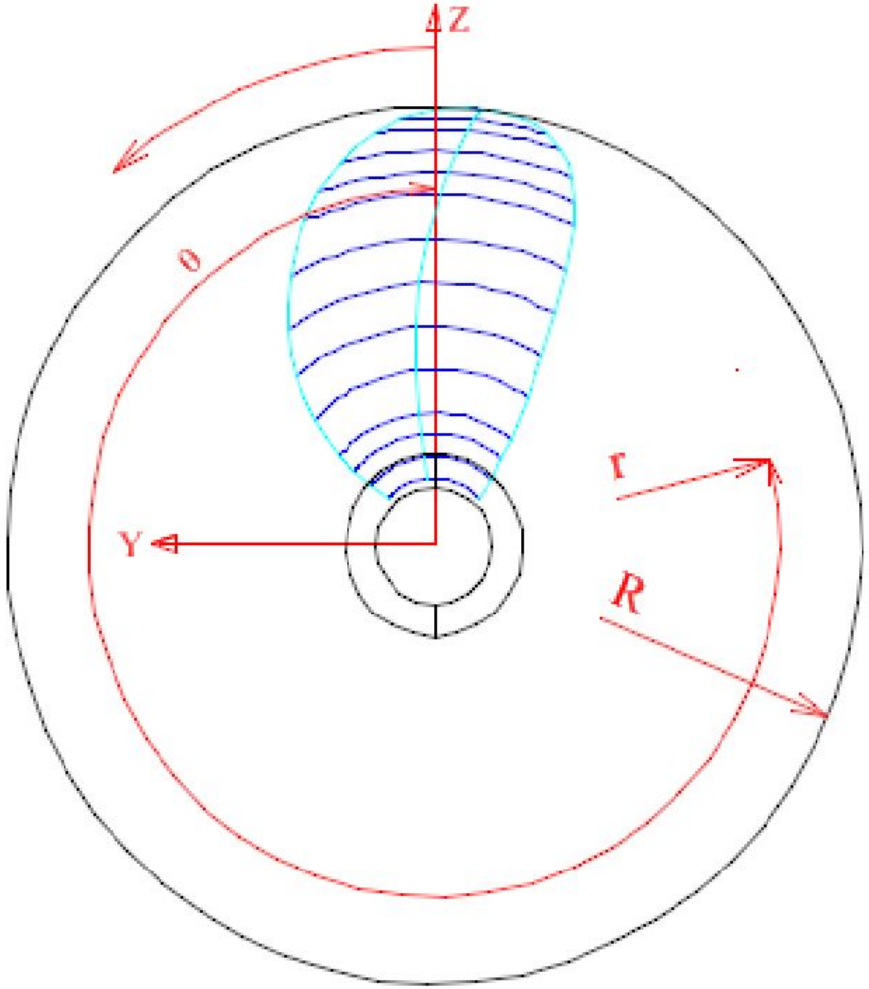
И всё то там не по-русски…

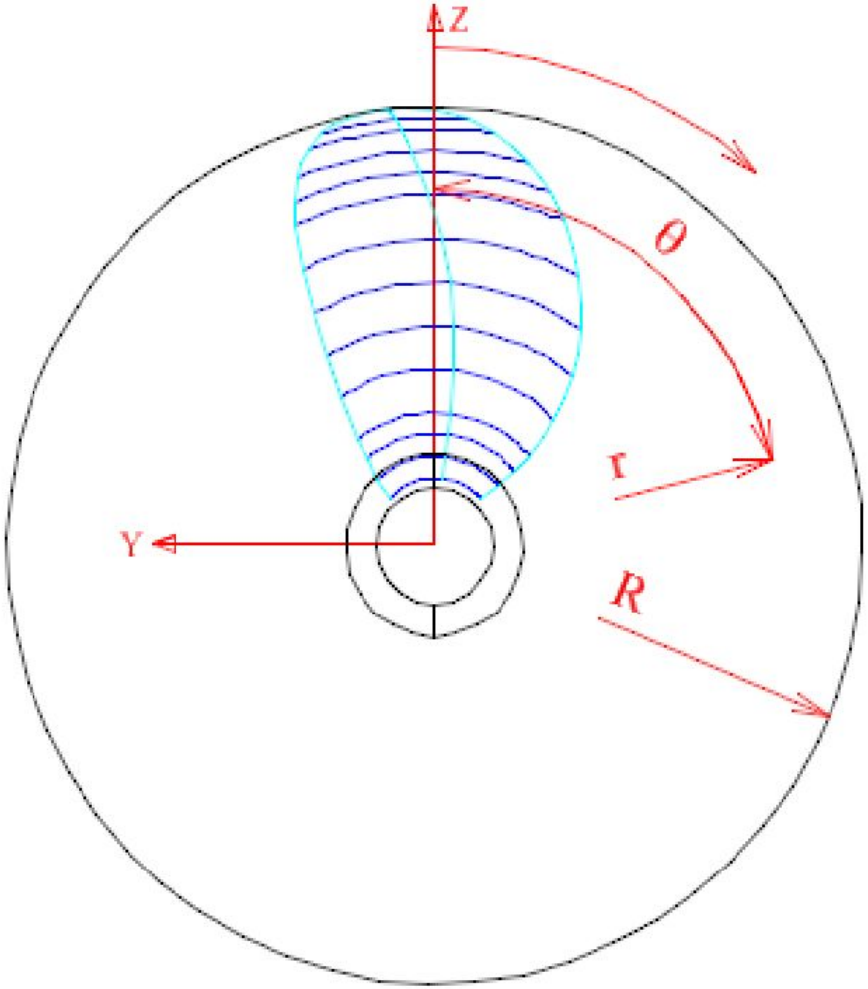
Dictionary of Ship Hydrodynamics

- Для описания геометрии движителей допускается применение локальных (a local reference frame) систем координат, к примеру, вращающейся (показано красненьким)

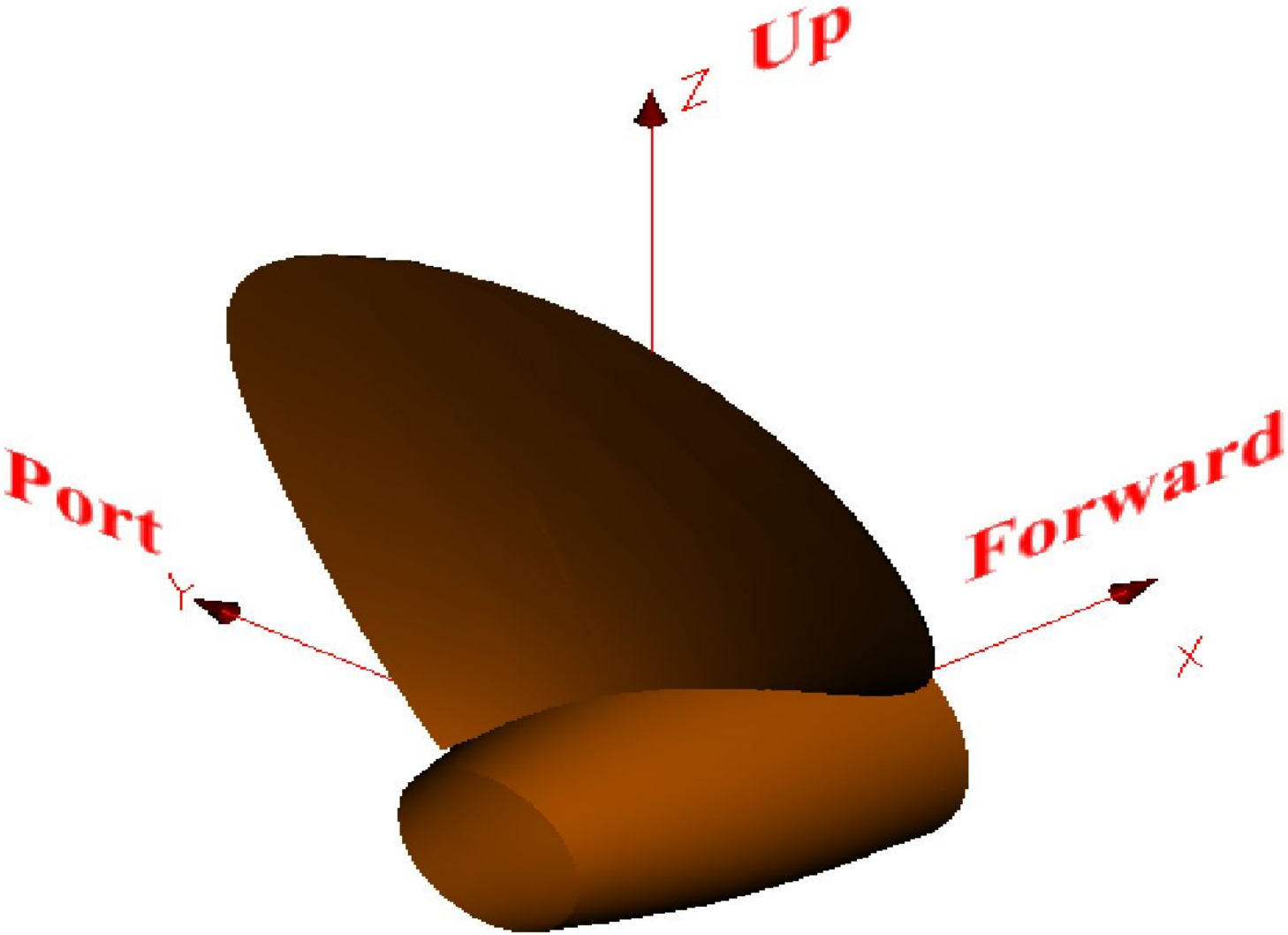


Основная цилиндрическая система координат - (вид сзади)



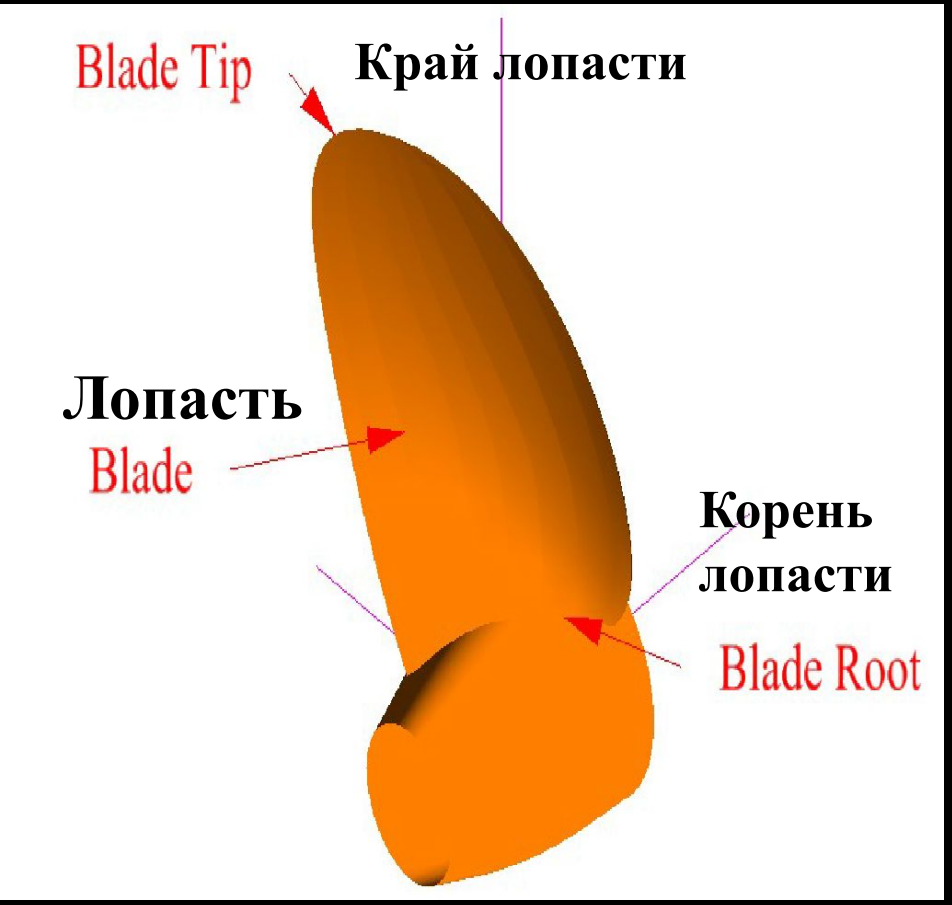


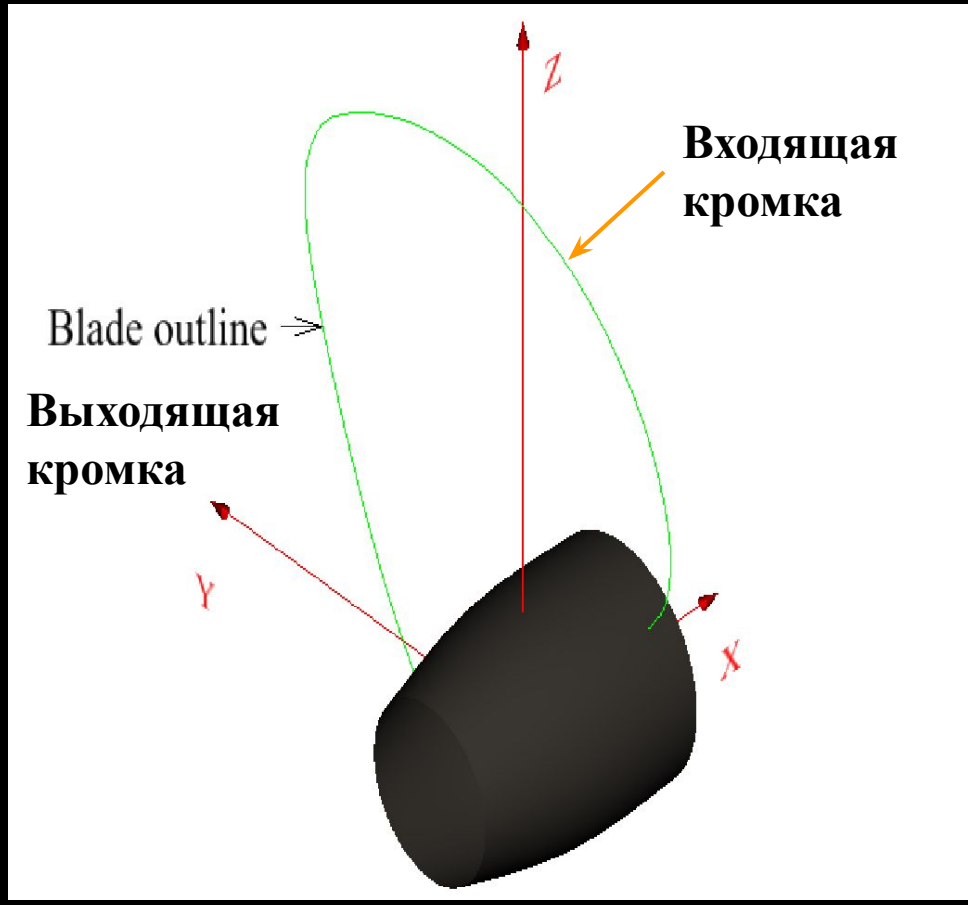
Декартова система координат



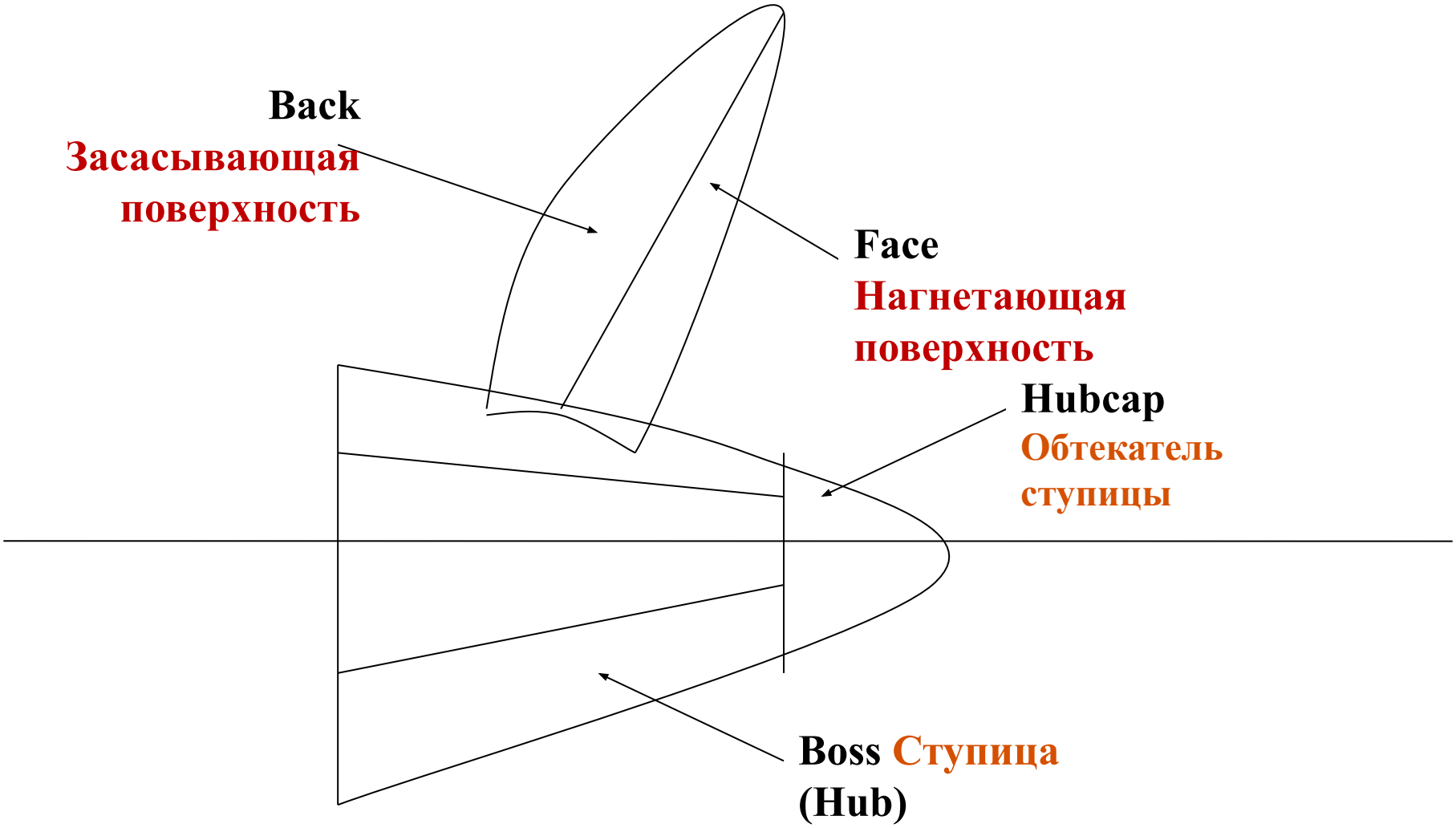
Описание гребных винтов

Основные понятия и определения





Гребной винт: геометрия и терминология



Propeller Materials\ МАТЕРИАЛ ГВ

Manganese bronze
Nickel manganese bronze
Nickel aluminum bronze
CF-4 Stainless steel

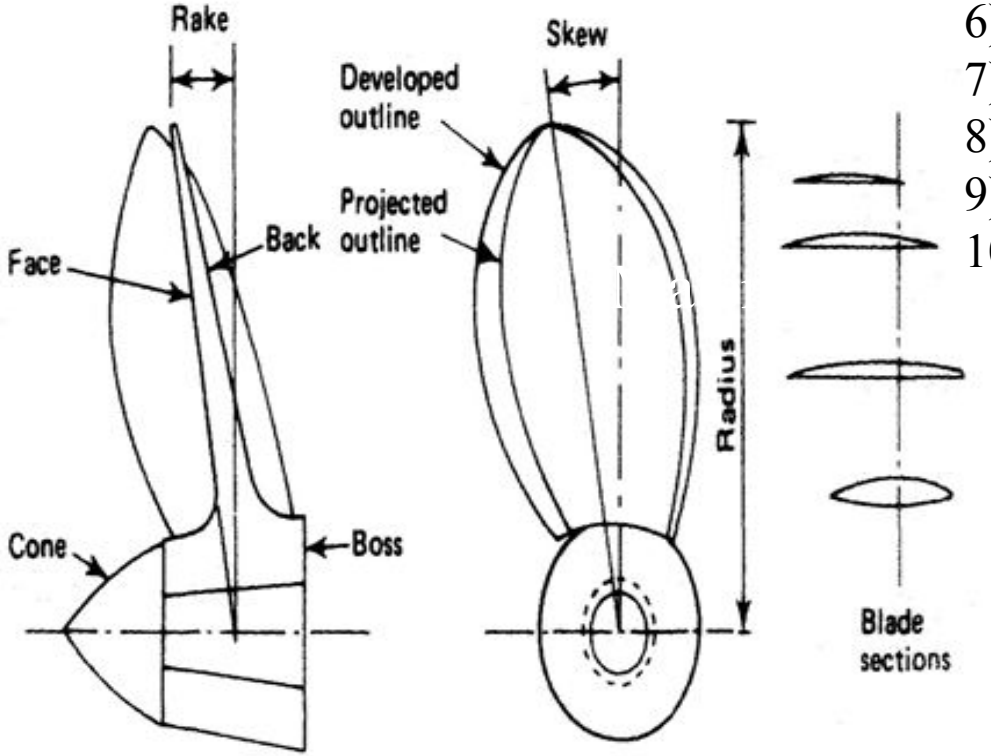
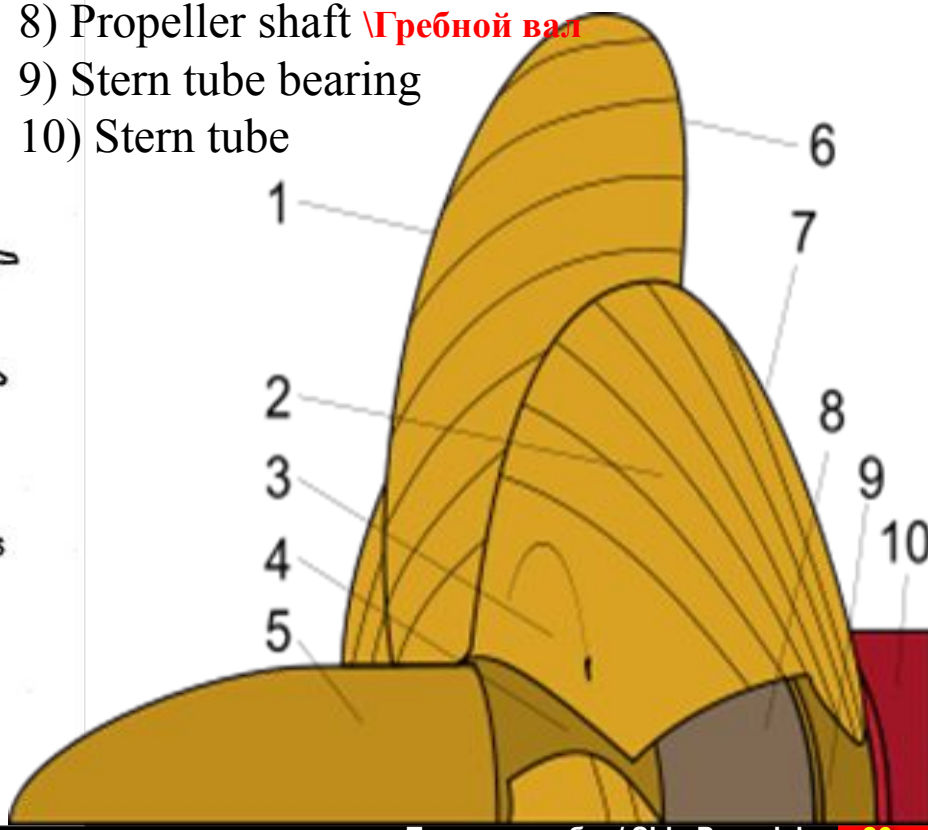
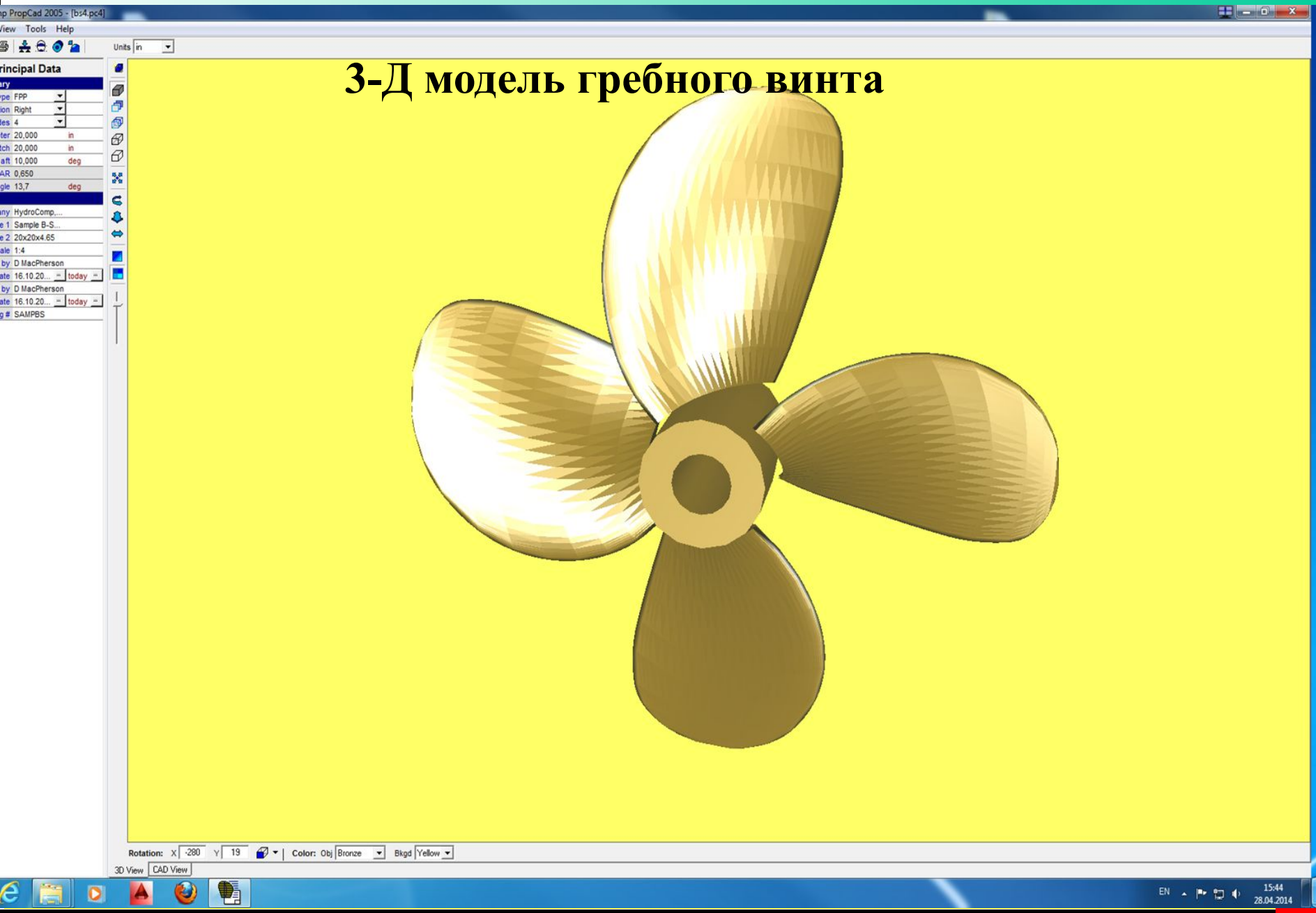


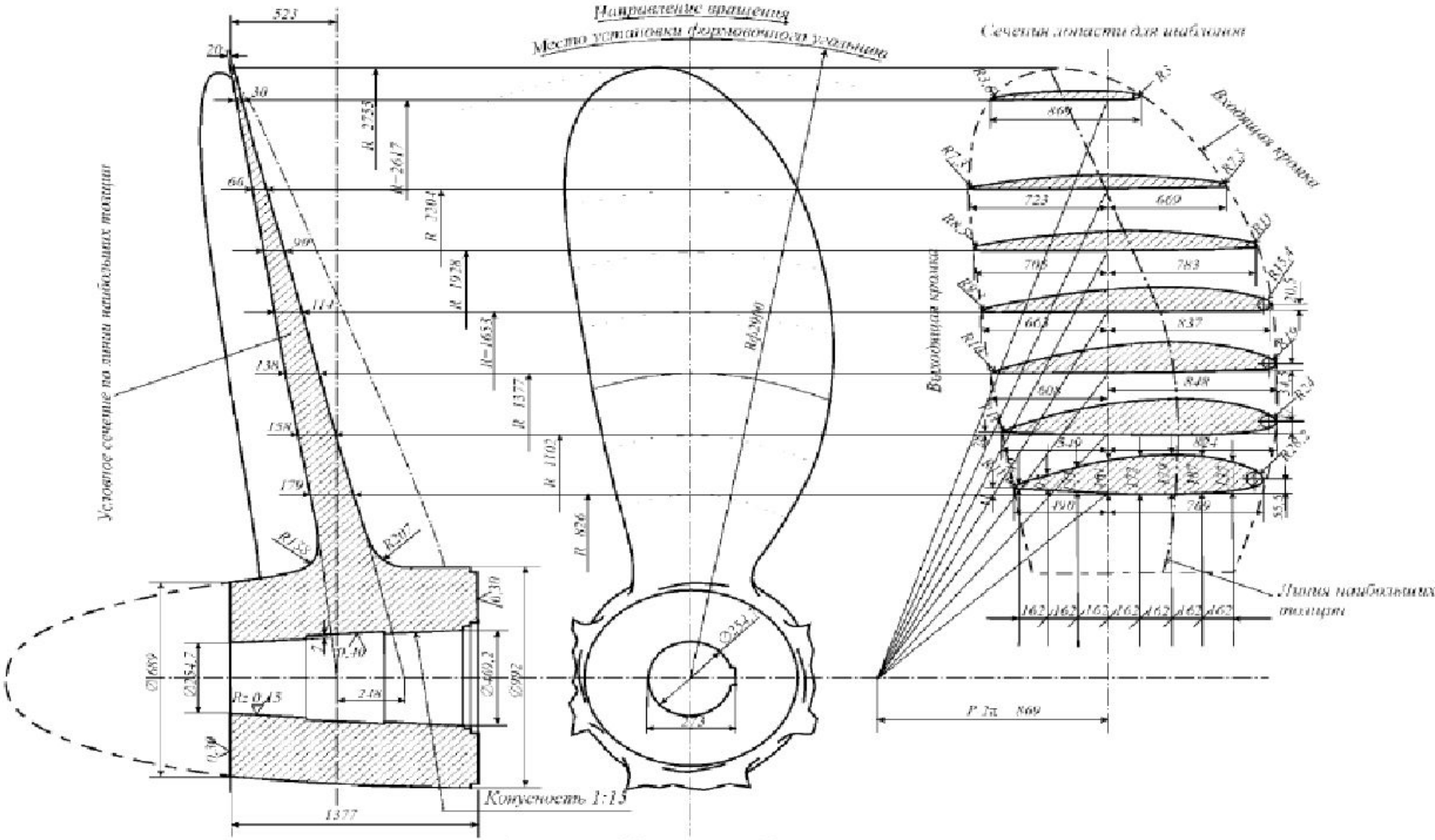
Figure 11.5 Solid propeller

1) Trailing edge\Выходящая кромка
2) Face \нагнетающая поверхность
3) Fillet area \галтель корня лопасти
4) Hub or Boss\Ступица
5) Hub or Boss Cap\Обтекатель ступицы
6) Leading edge\Входящая кромка
7) Back \засасывающая поверхность
8) Propeller shaft \Гребной вал
9) Stern tube bearing
10) Stern tube



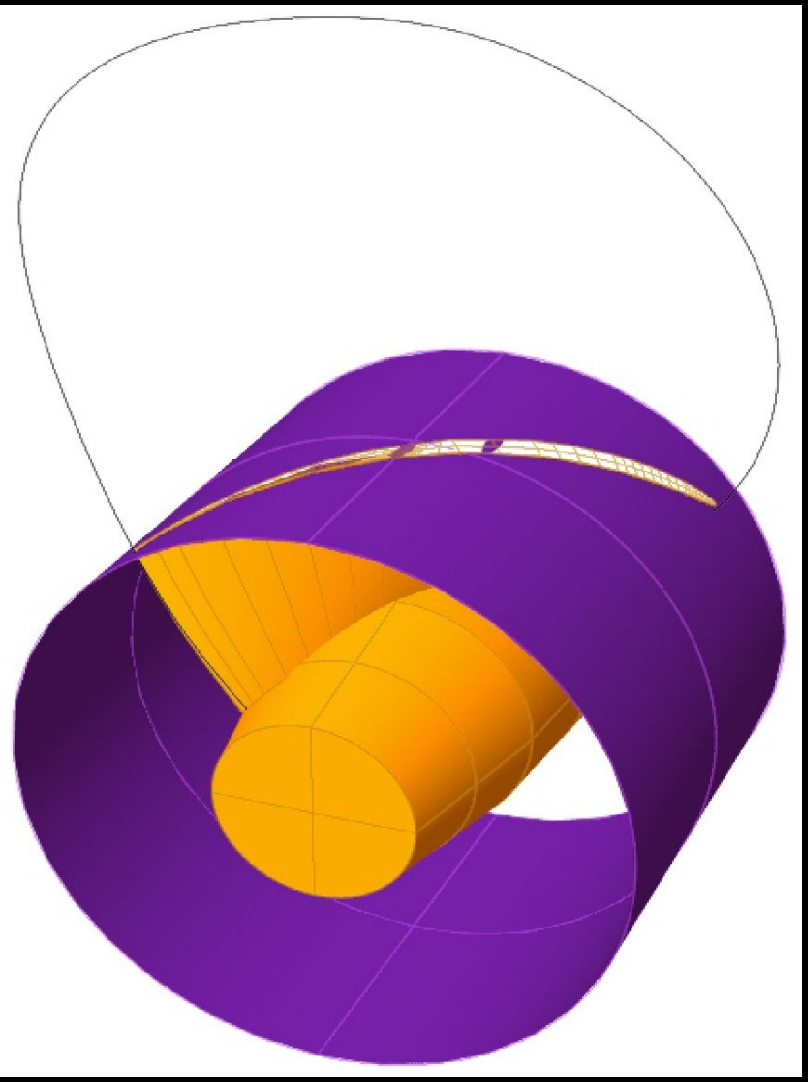
3-Д модель гребного винта

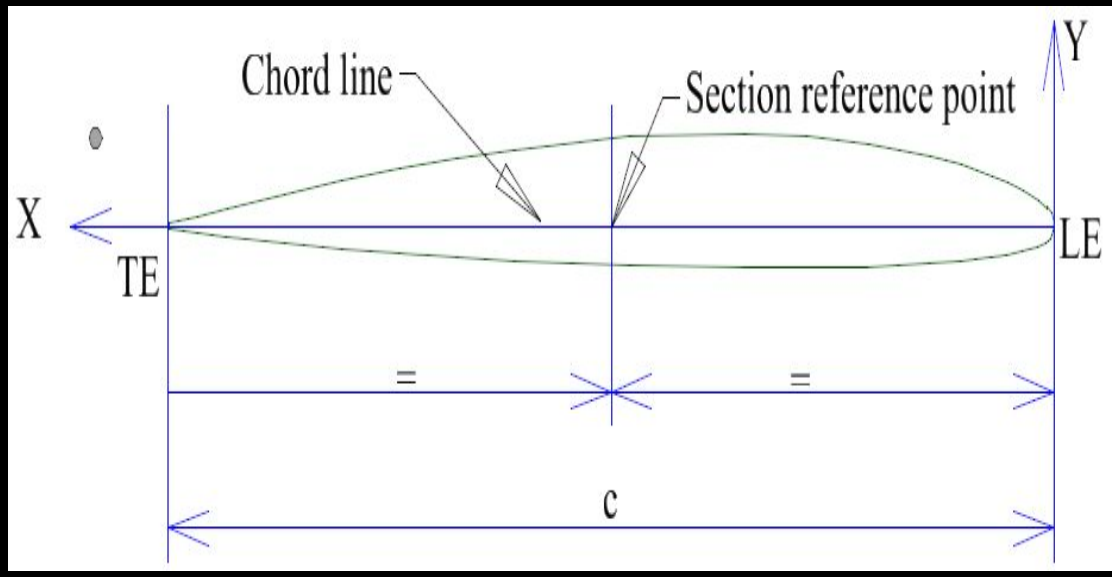


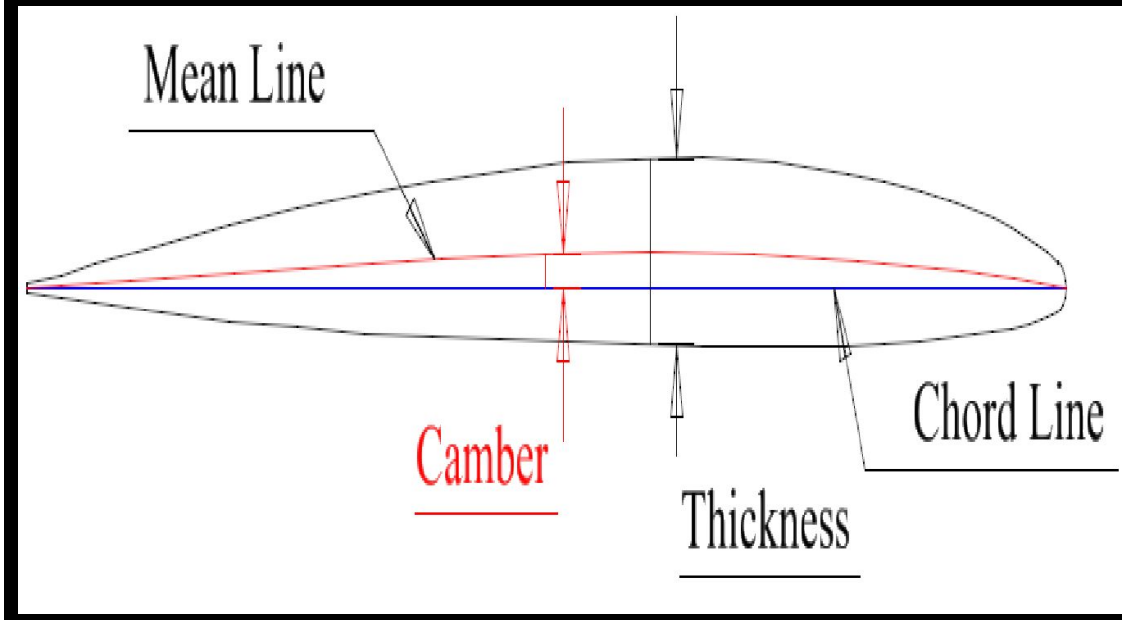


Чертеж гребного винта

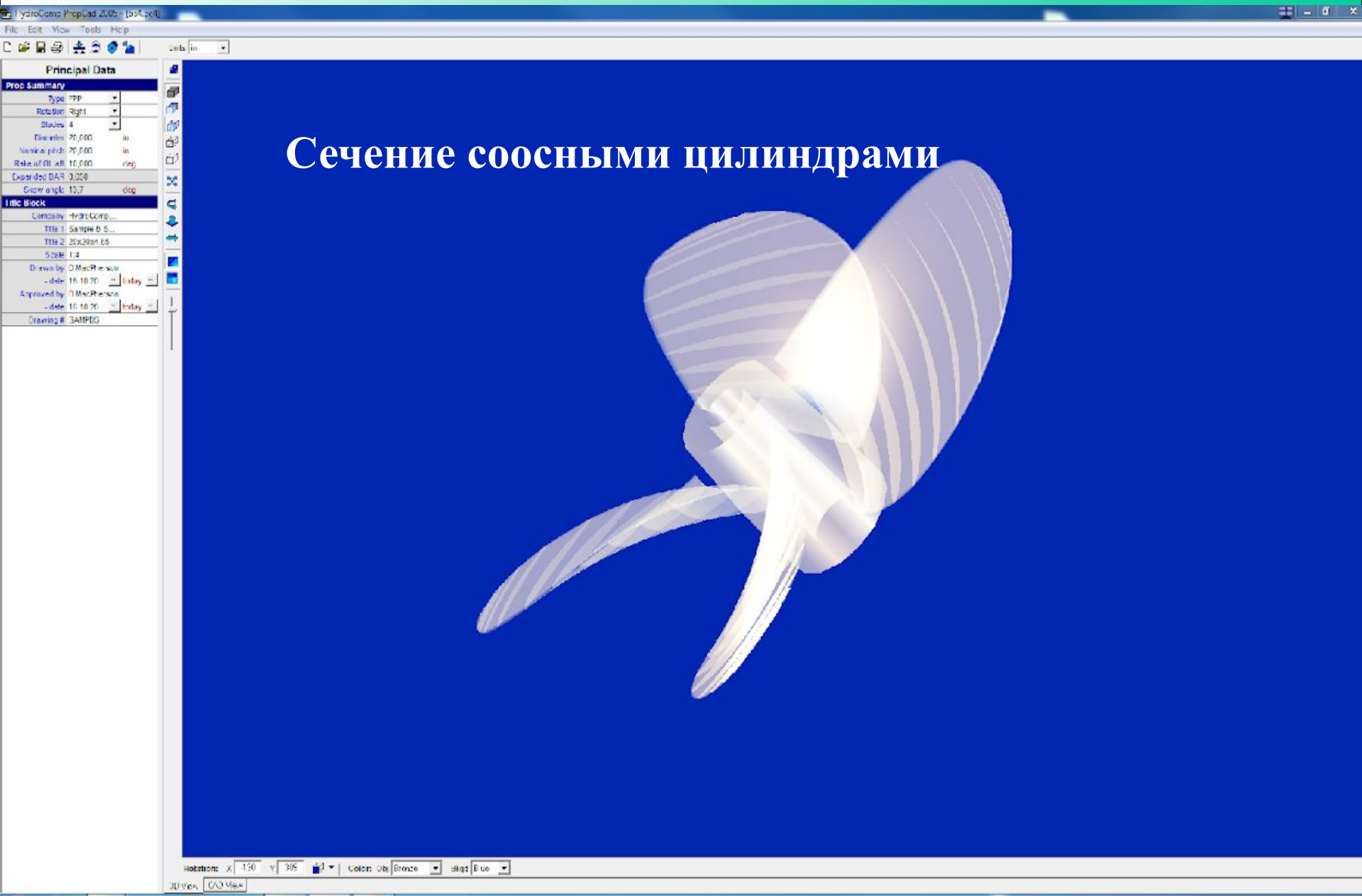
Сечение соосным цилиндром



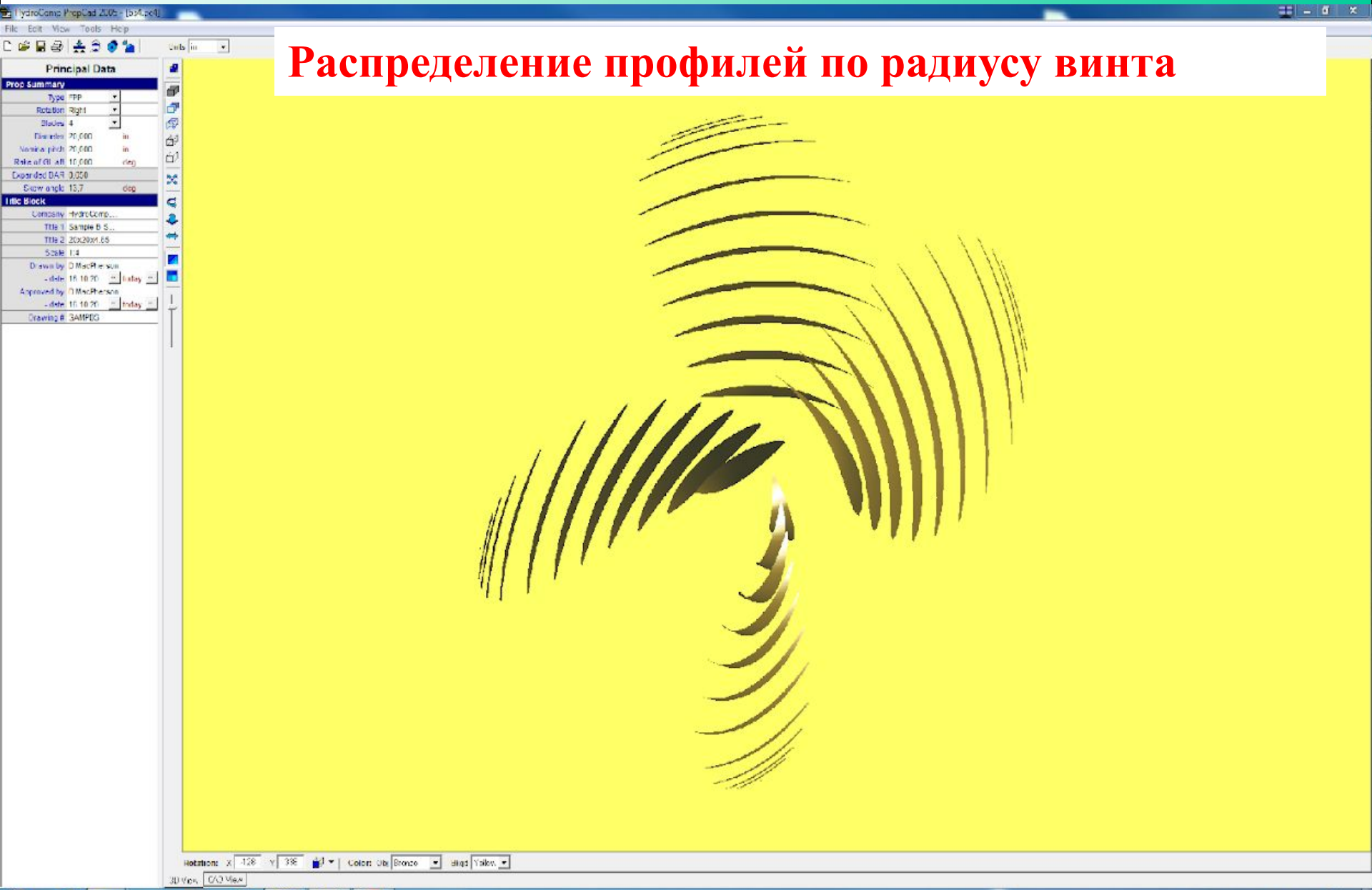


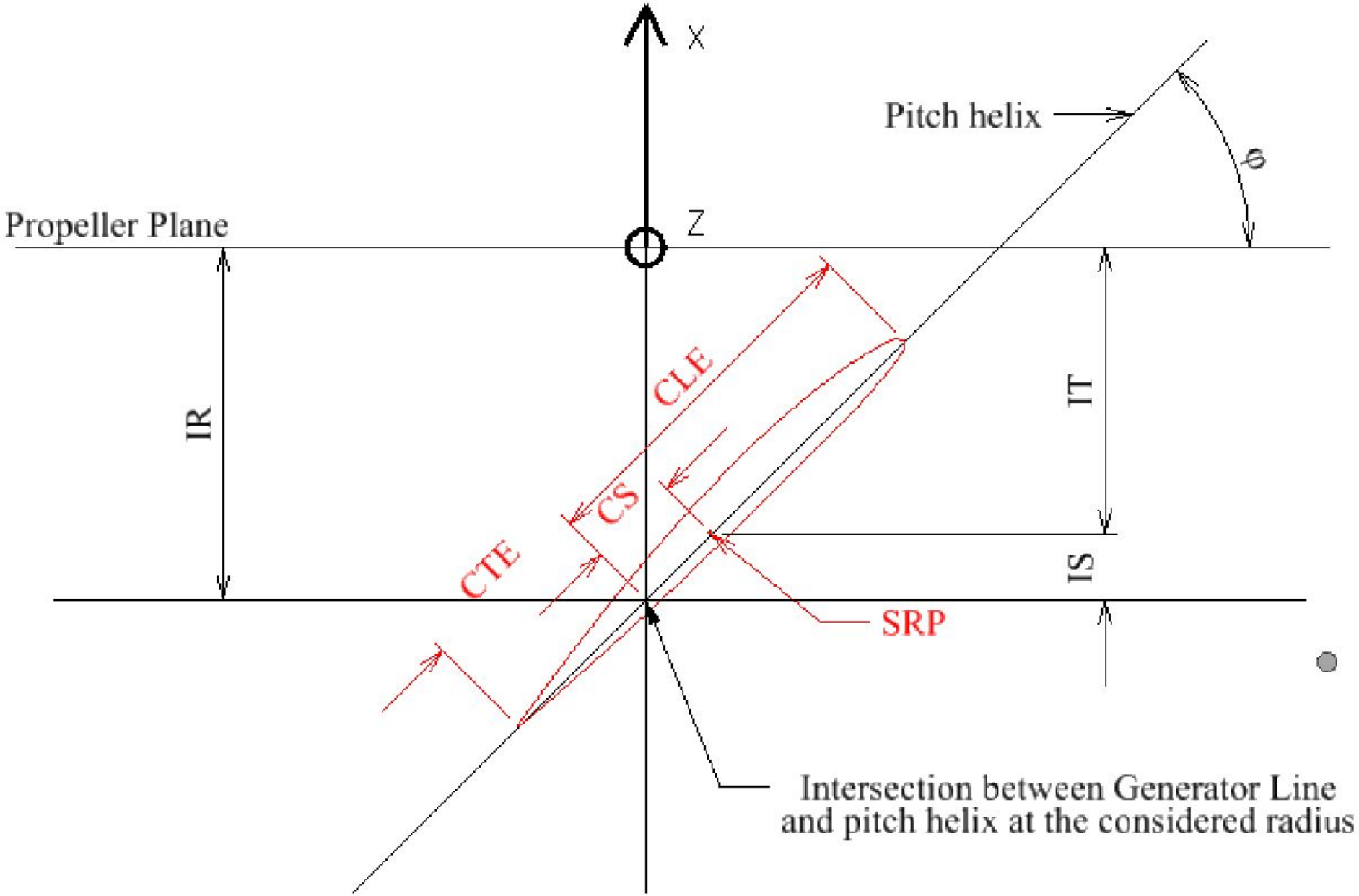


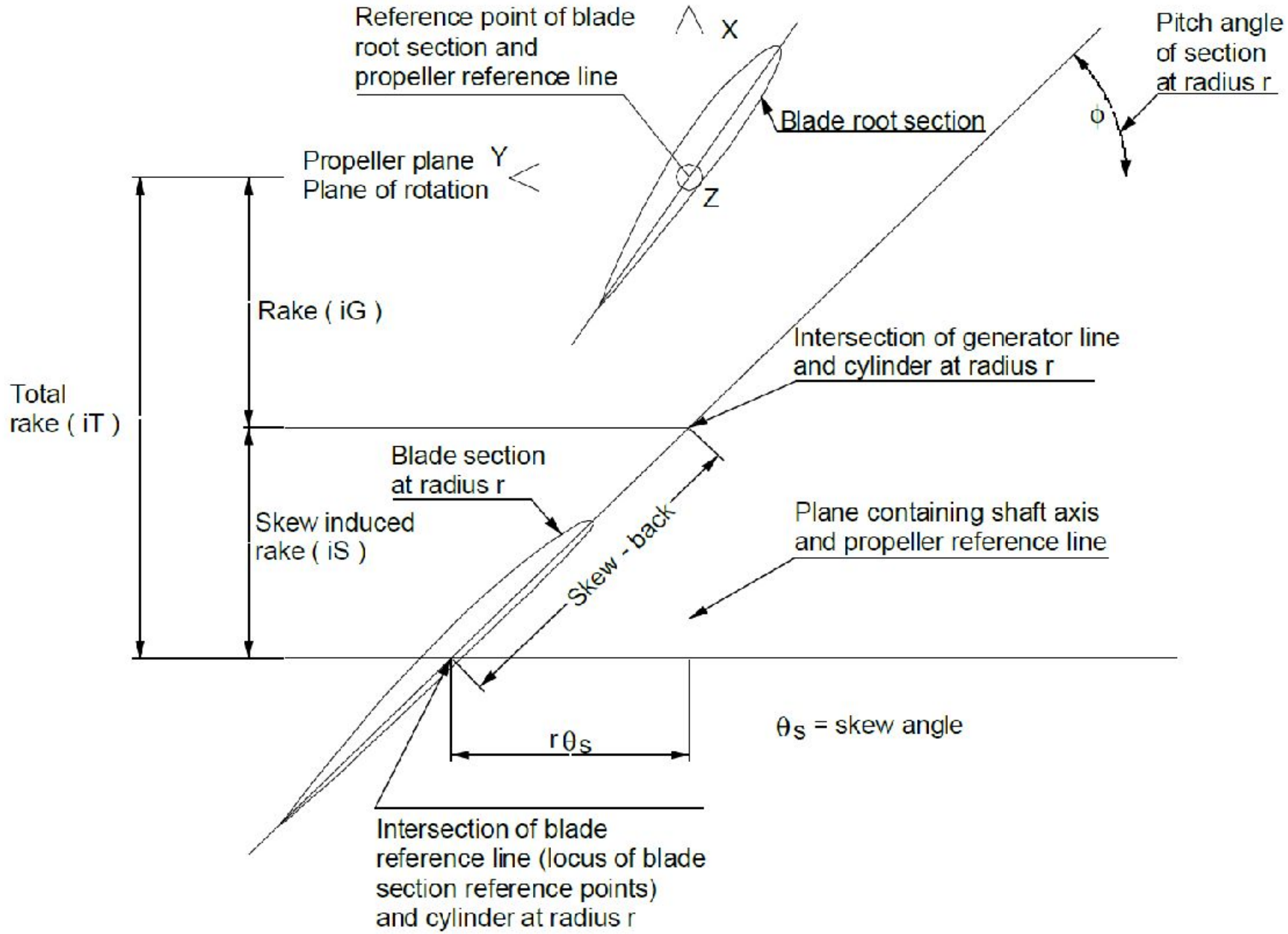
Сечение соосными цилиндрами

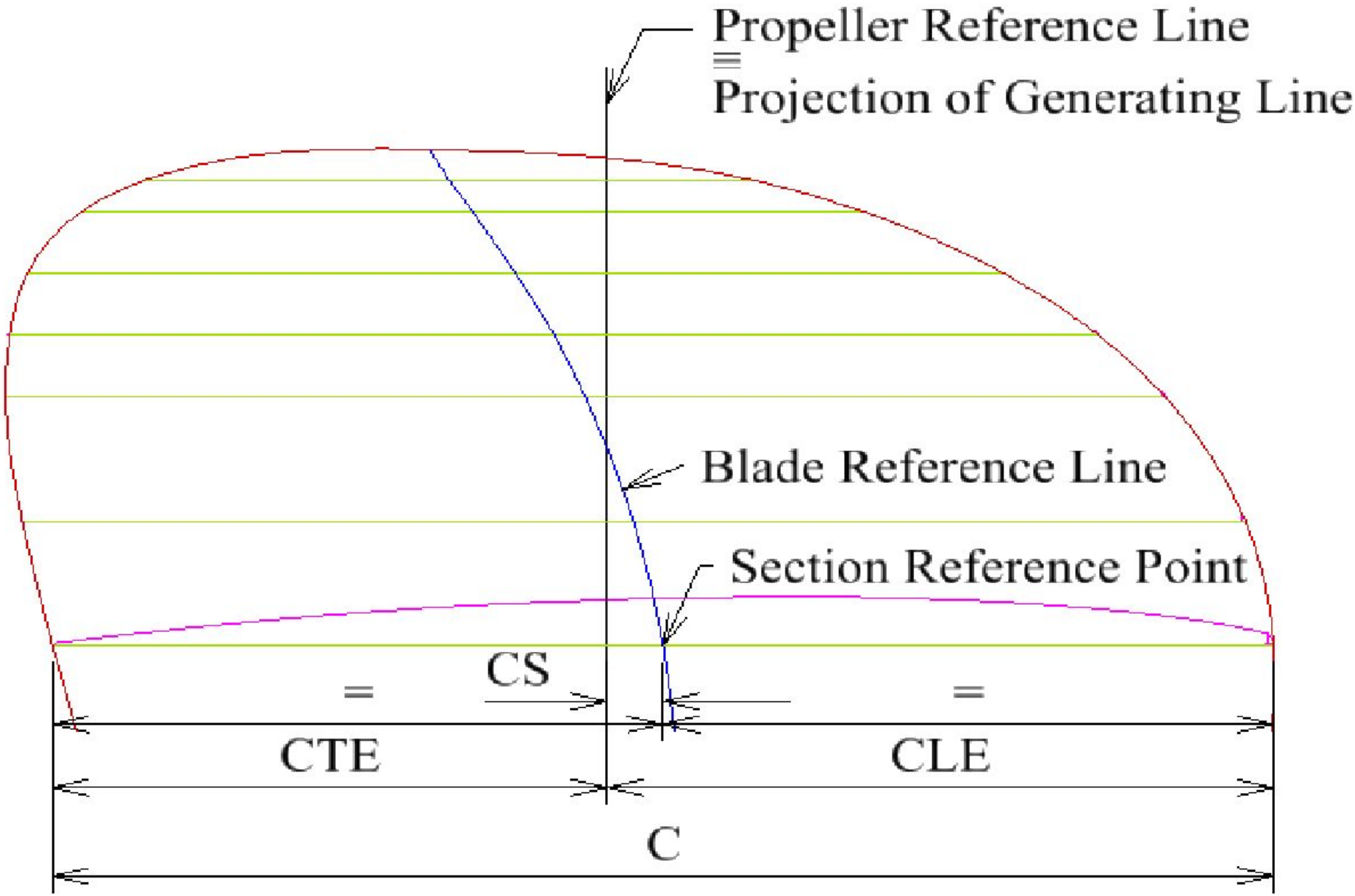


Распределение профилей по радиусу винта

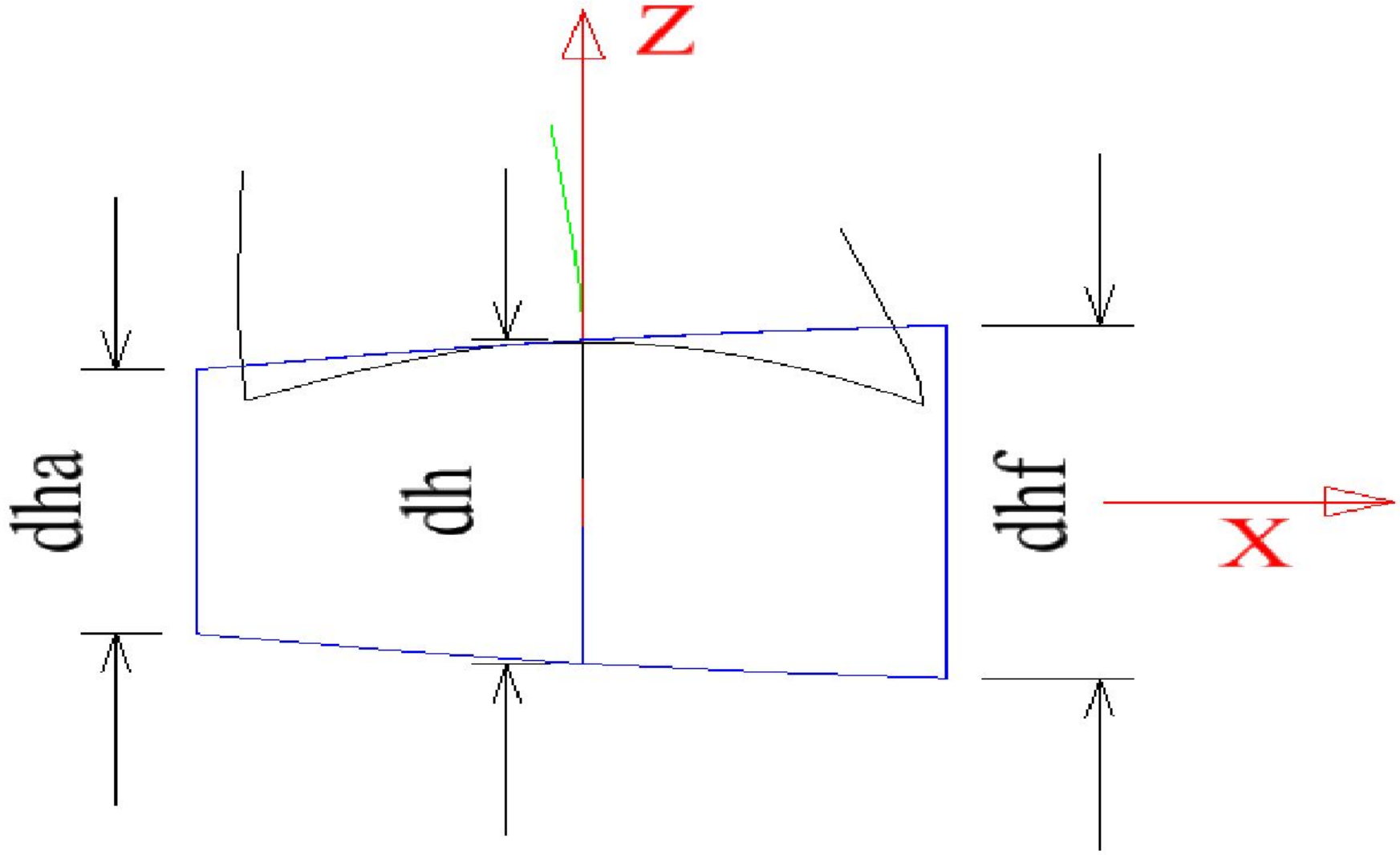



X
Pitch helix
φ
Propeller Plane
Z
IR
CLE
CS
CTE
IT
IS
SRP
Intersection between Generator Line
and pitch helix at the considered radius

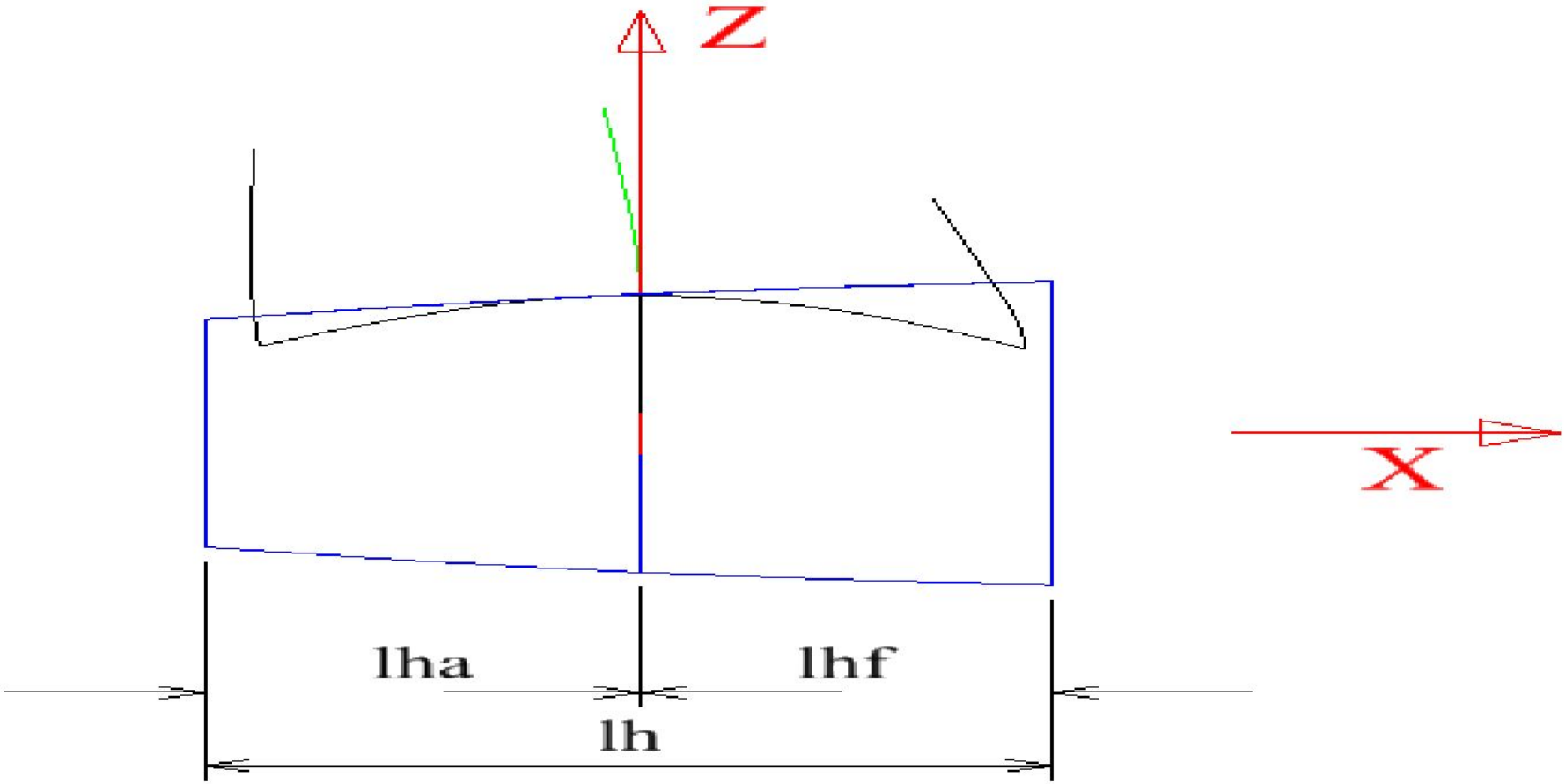

Reference point of blade root section and propeller reference line
X
Pitch angle of section at radius r
Blade root section
ϕ
Propeller plane
Plane of rotation
Y
Z
Rake (iG)
Intersection of generator line and cylinder at radius r
Total rake (iT)
Blade section at radius r
Skew induced rake (iS)
Skew - back
Plane containing shaft axis and propeller reference line
rθs
θs = skew angle
Intersection of blade reference line (locus of blade section reference points) and cylinder at radius r


Propeller Reference Line
≡
Projection of Generating Line
Blade Reference Line
Section Reference Point
CS
=
=
CTE
CLE
C

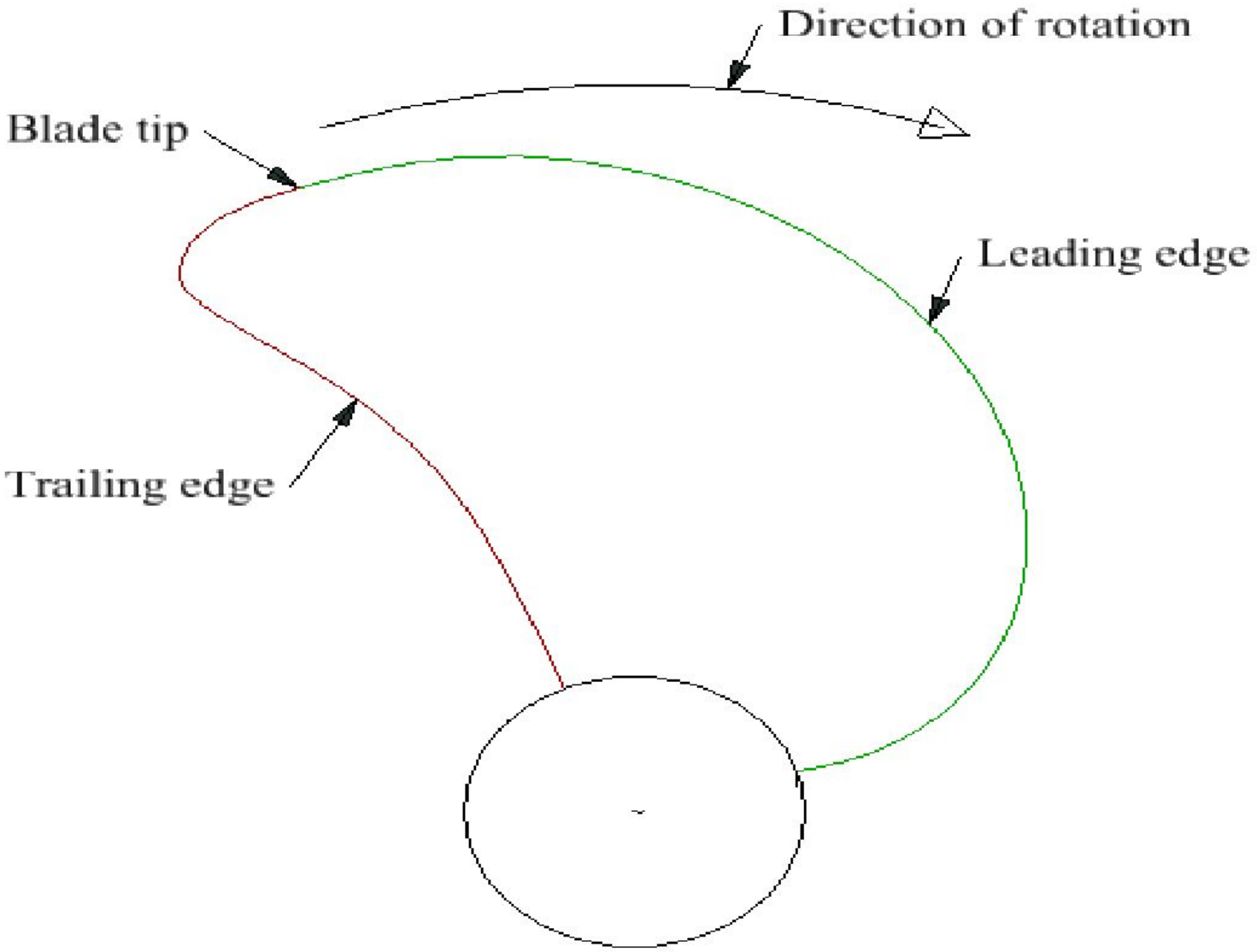
Диаметры ступицы



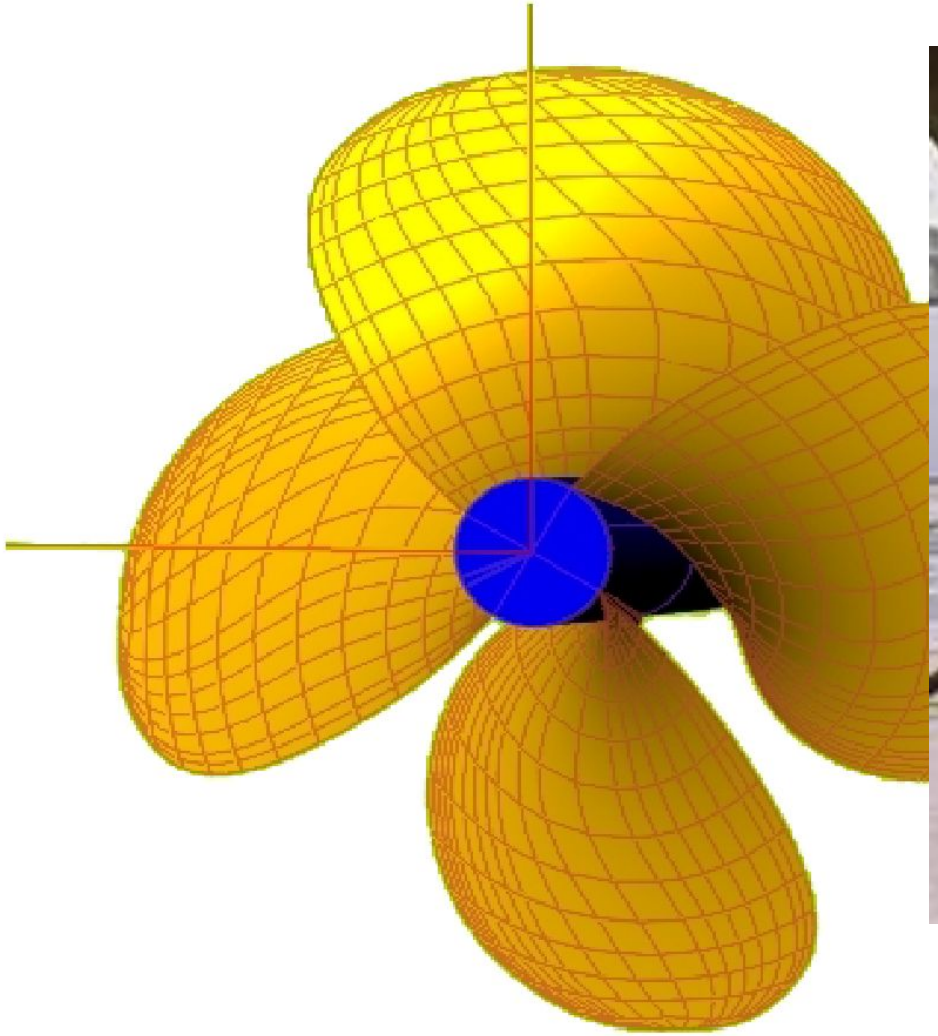
Продольные размеры ступицы



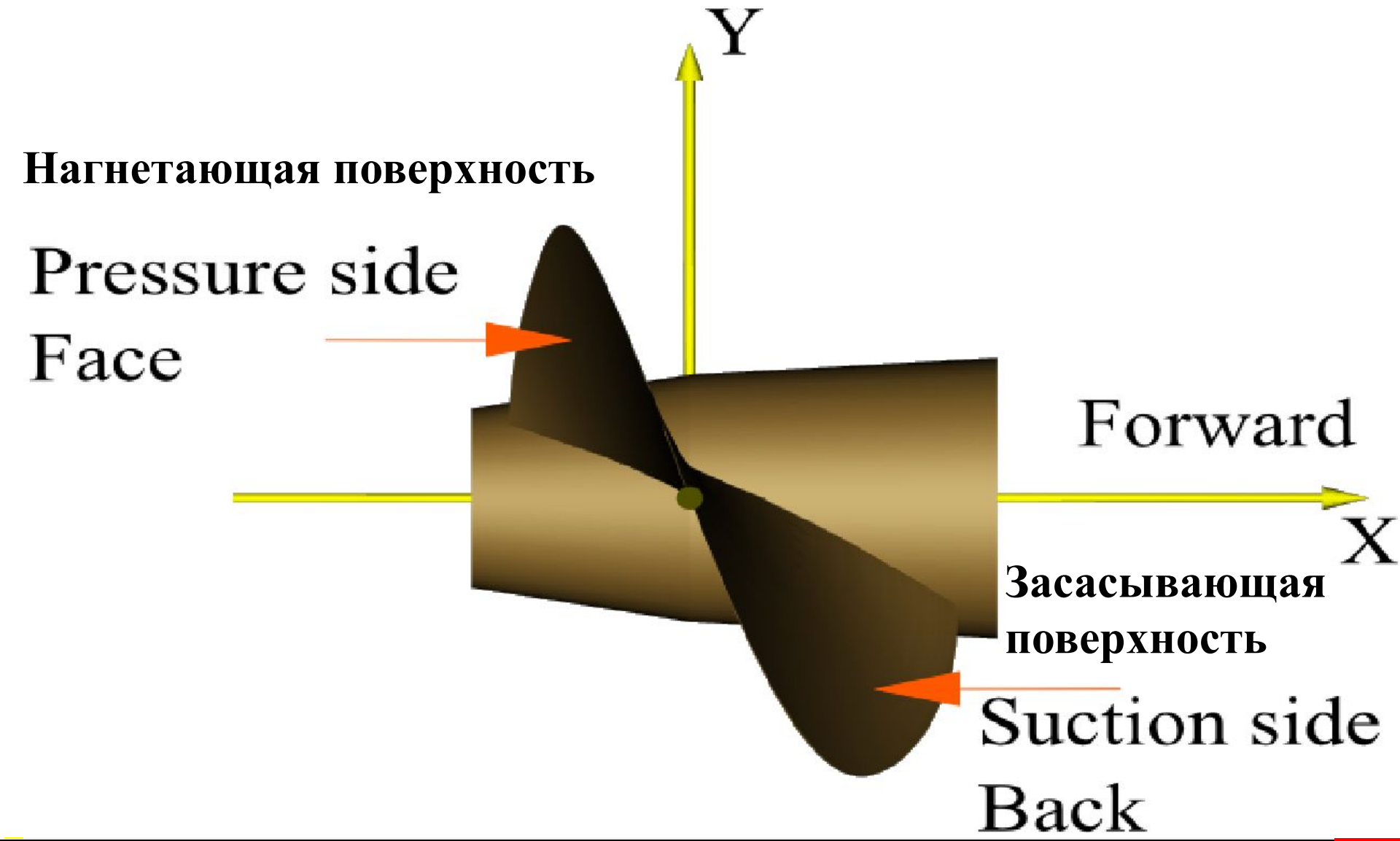
Входящая и выходящая кромки лопасти винта



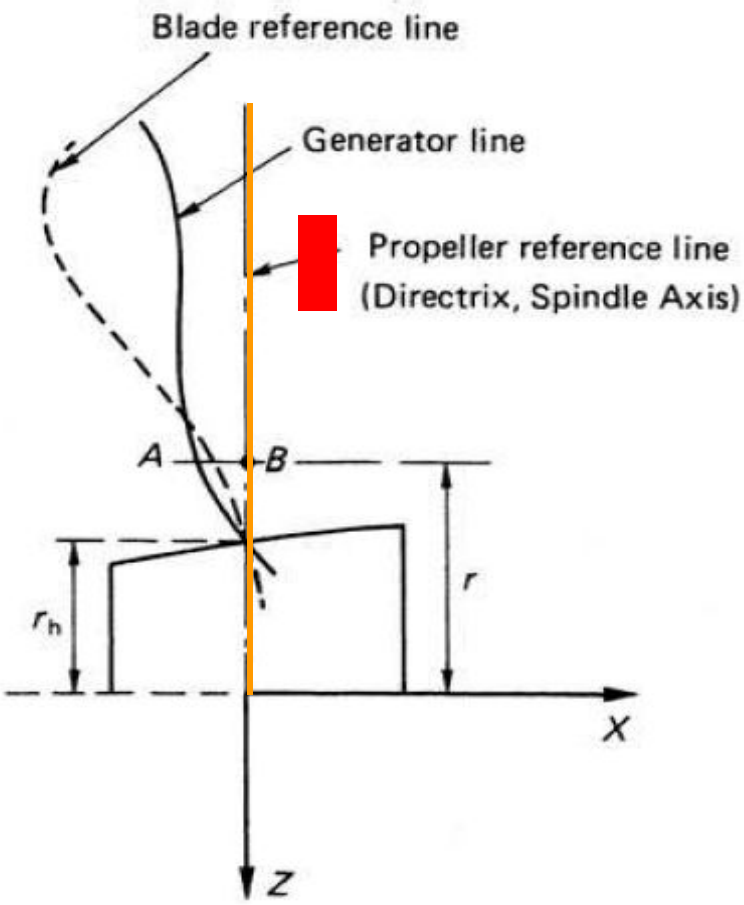
Screw propeller (Поверхность винта)

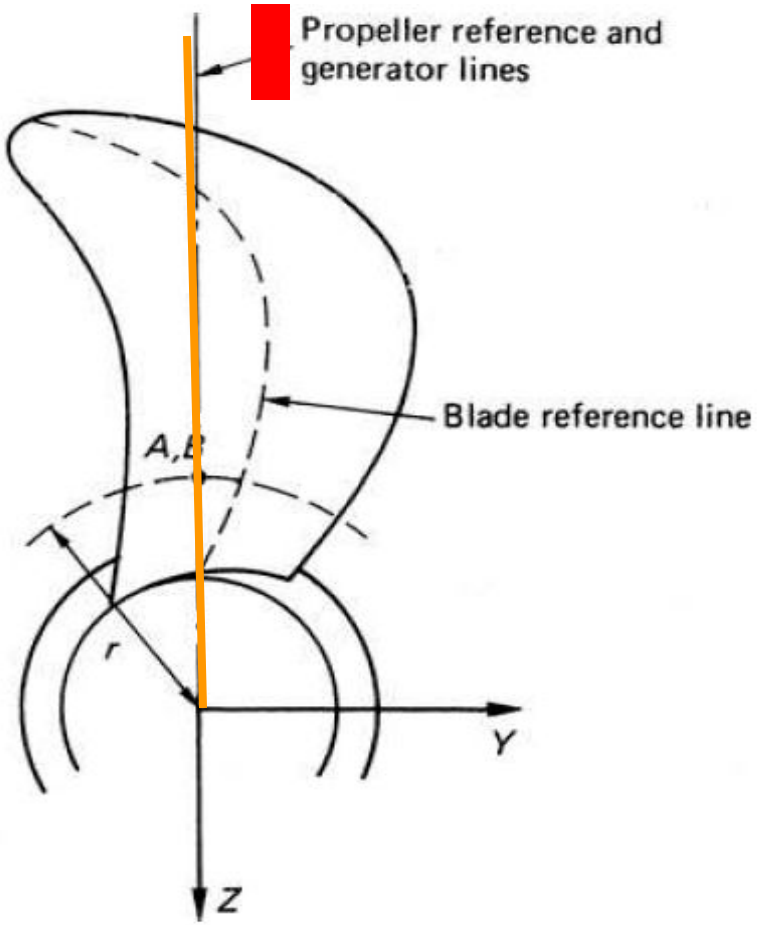


Поверхности гребного винта

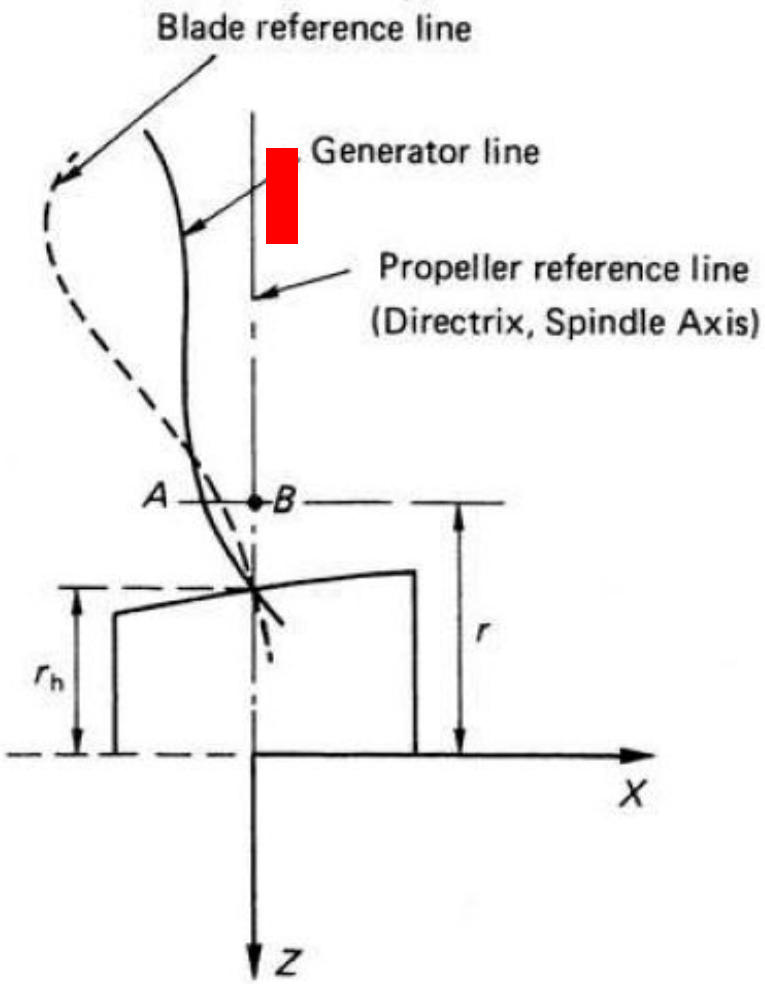


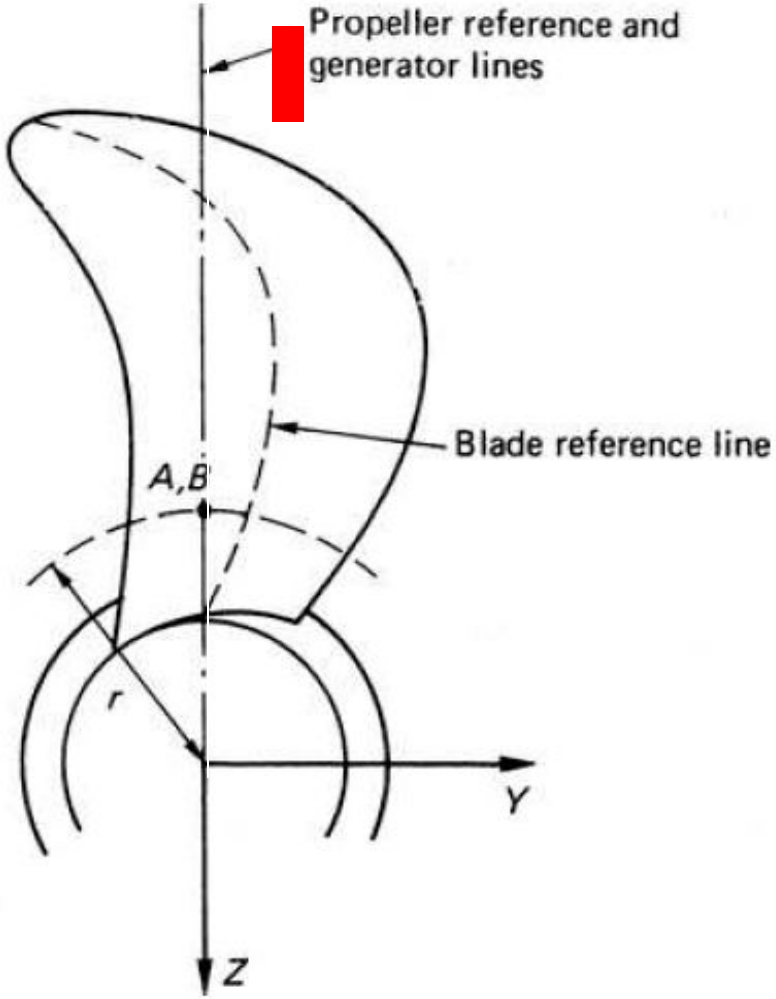
- **Основная линия** - линия, перпендикулярная оси вала
- (propeller **reference line** or **directrix**).



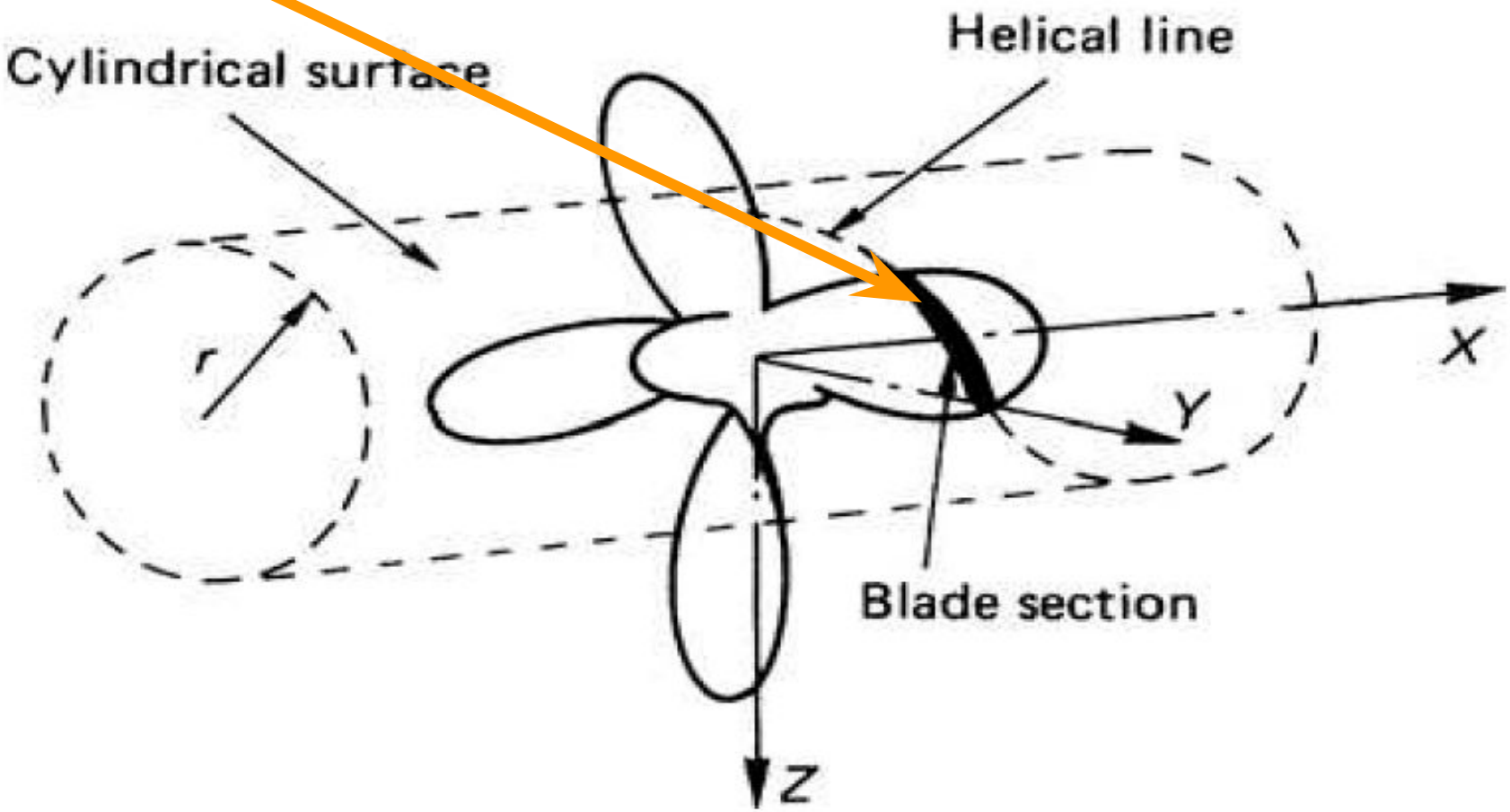


- **Generator line:** The line formed by intersection of the pitch helices and the plane containing the shaft axis and propeller reference line.
- **Образующая** – линия пересечения номинальной винтовой поверхности продольной плоскостью **XZ**

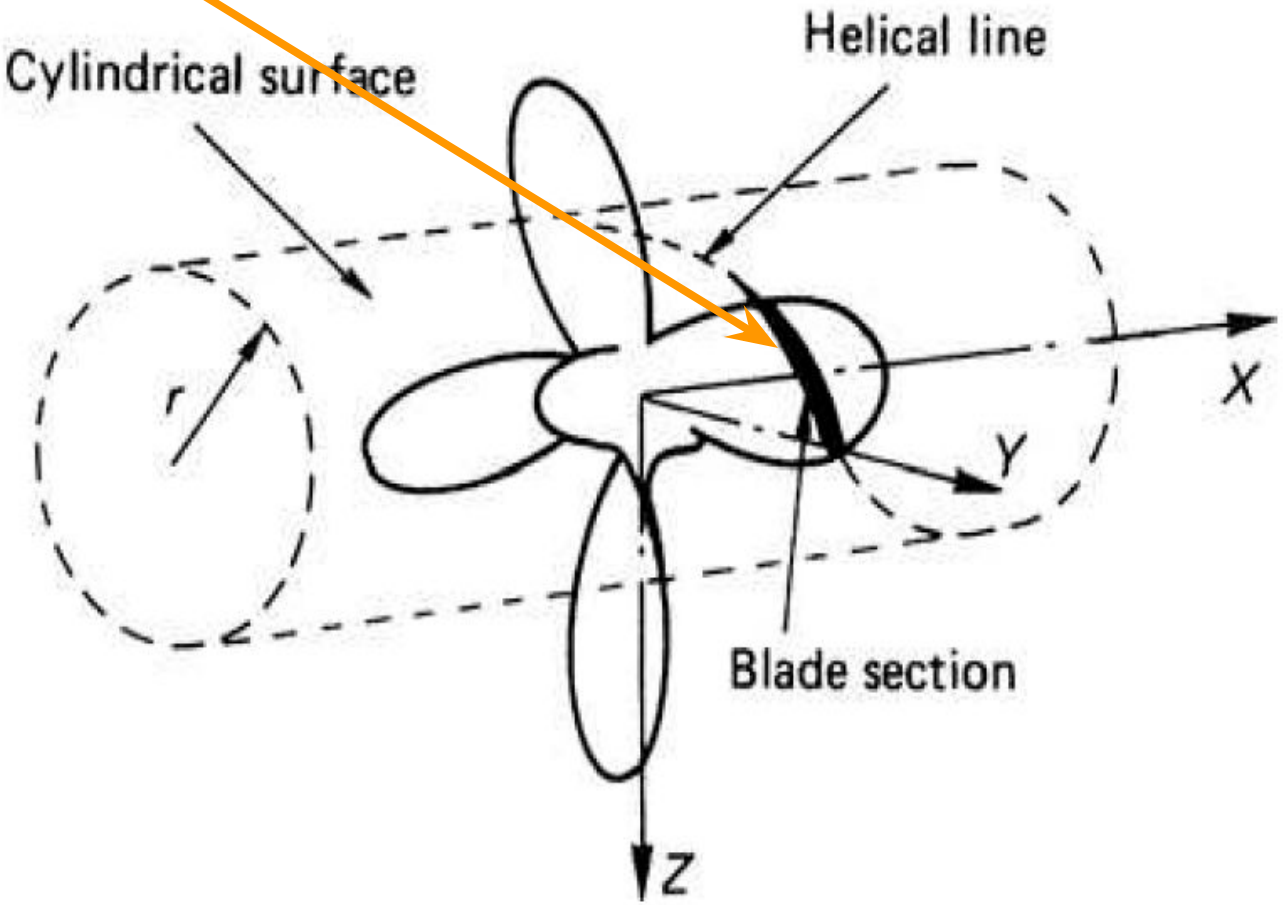




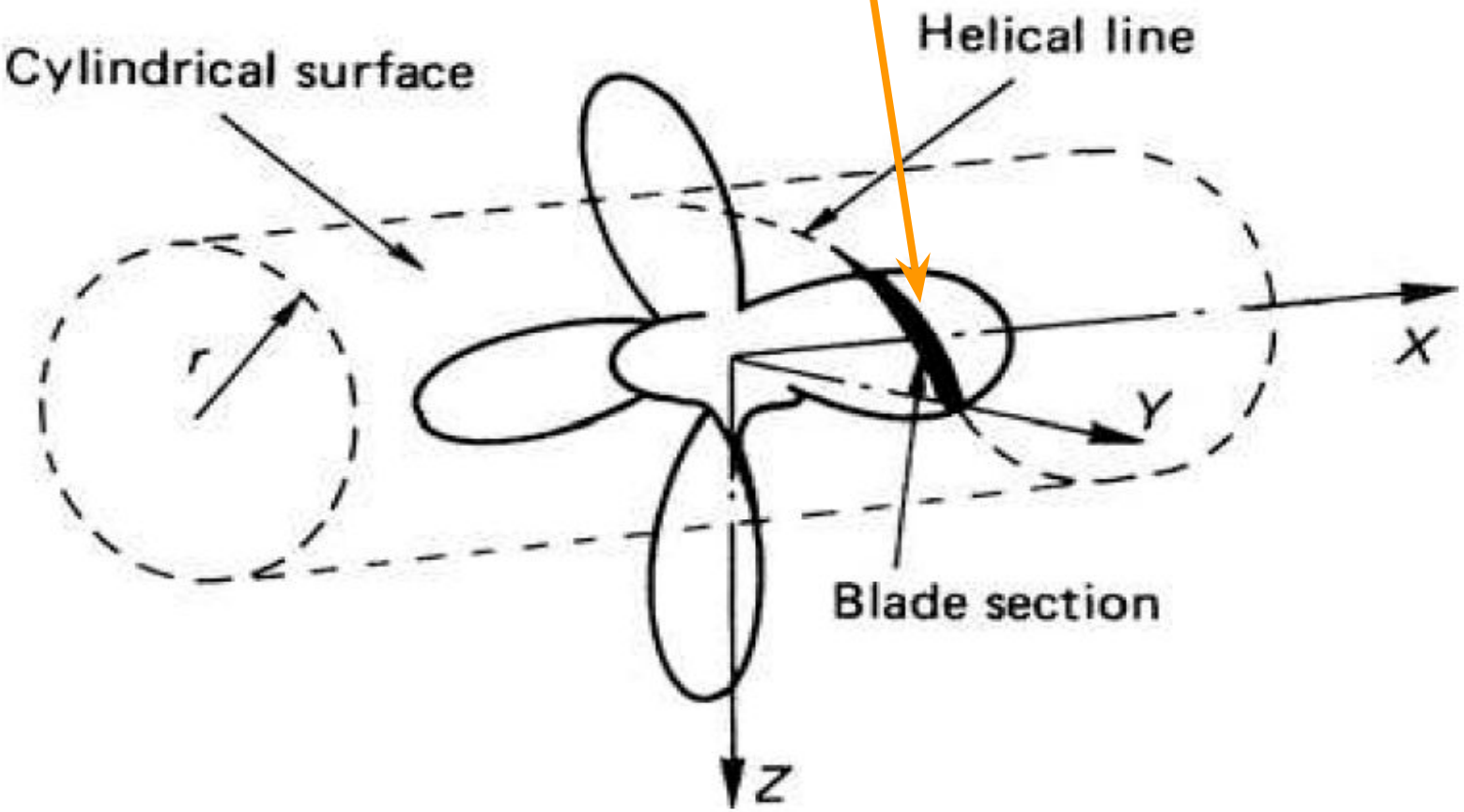
- The aerofoil sections which together comprise the blade of a propeller are defined on the surfaces of cylinders whose axes are concentric with the shaft axis.
- Профили – сечения лопасти соосными цилиндрами



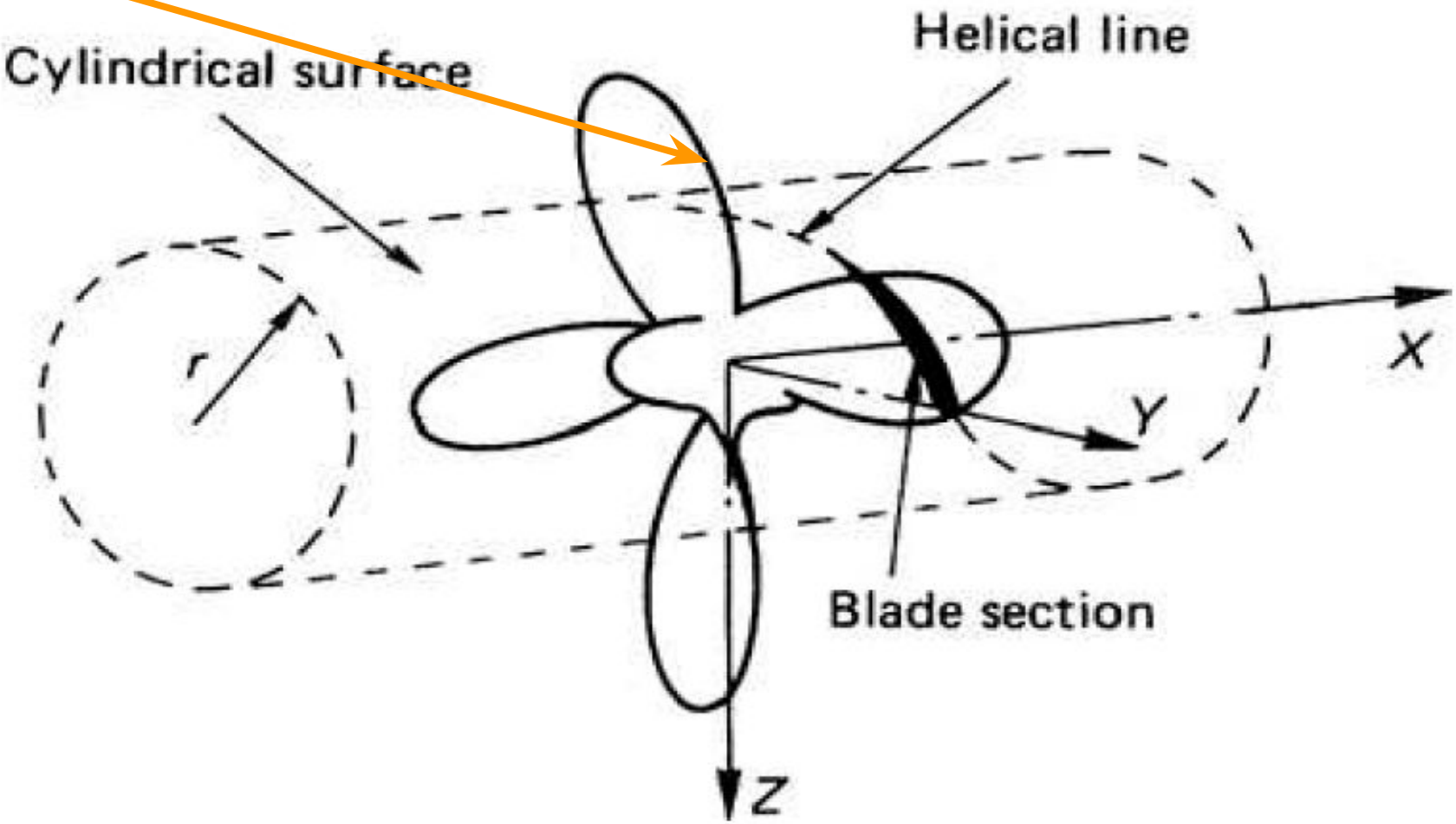
- Face: The side of a propeller blade which faces downstream during ahead motion is called face or pressure side (when viewed from aft of a ship to the bow the seen side of a propeller blade is called face or pressure side).
- Нагнетающая поверхность



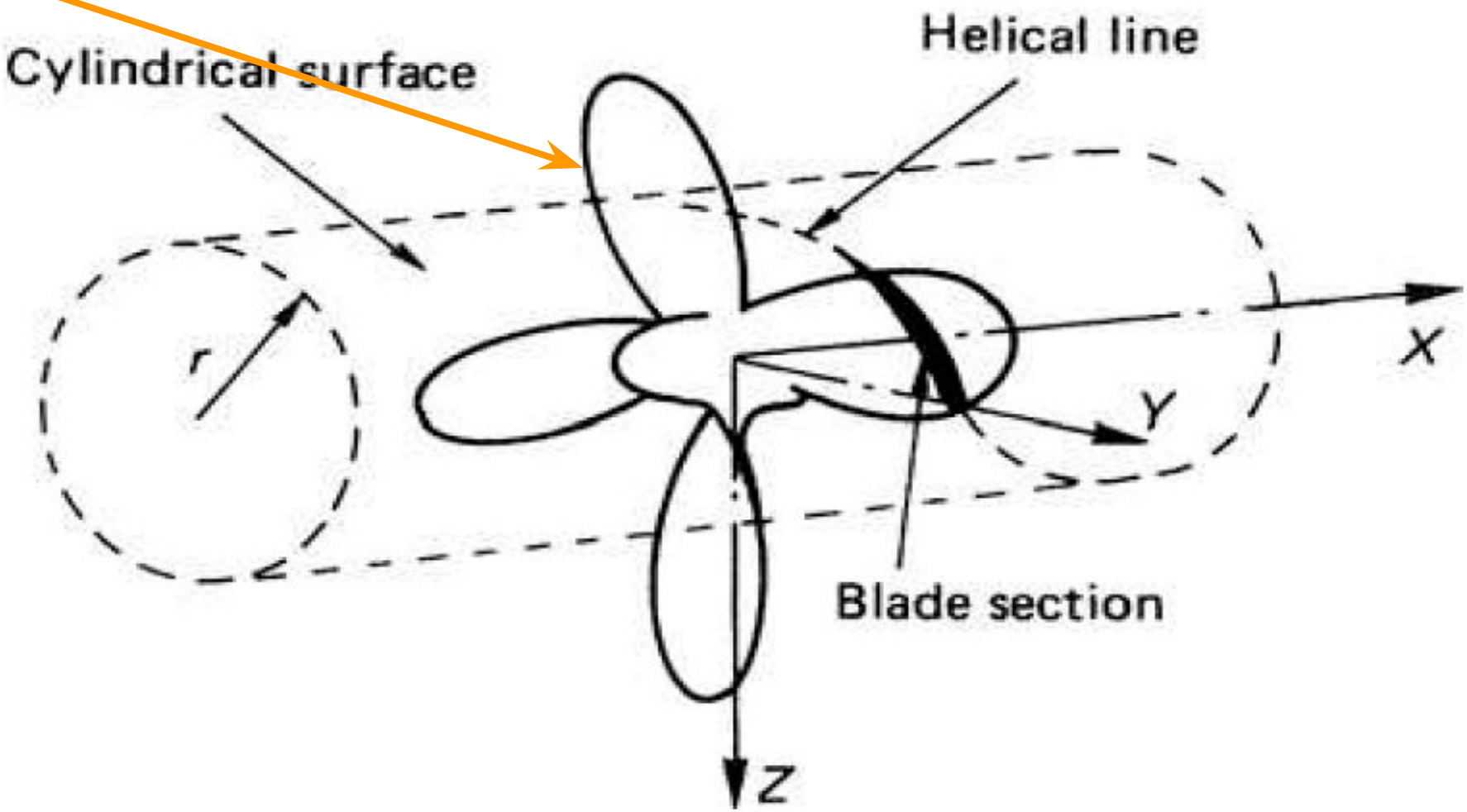
- **Back: The side of a propeller blade which faces generally direction of ahead motion is called back or suction side (when viewed from aft of a ship to the bow the unseen side of a propeller blade is called back or suction side).**
- **Засасывающая поверхность**

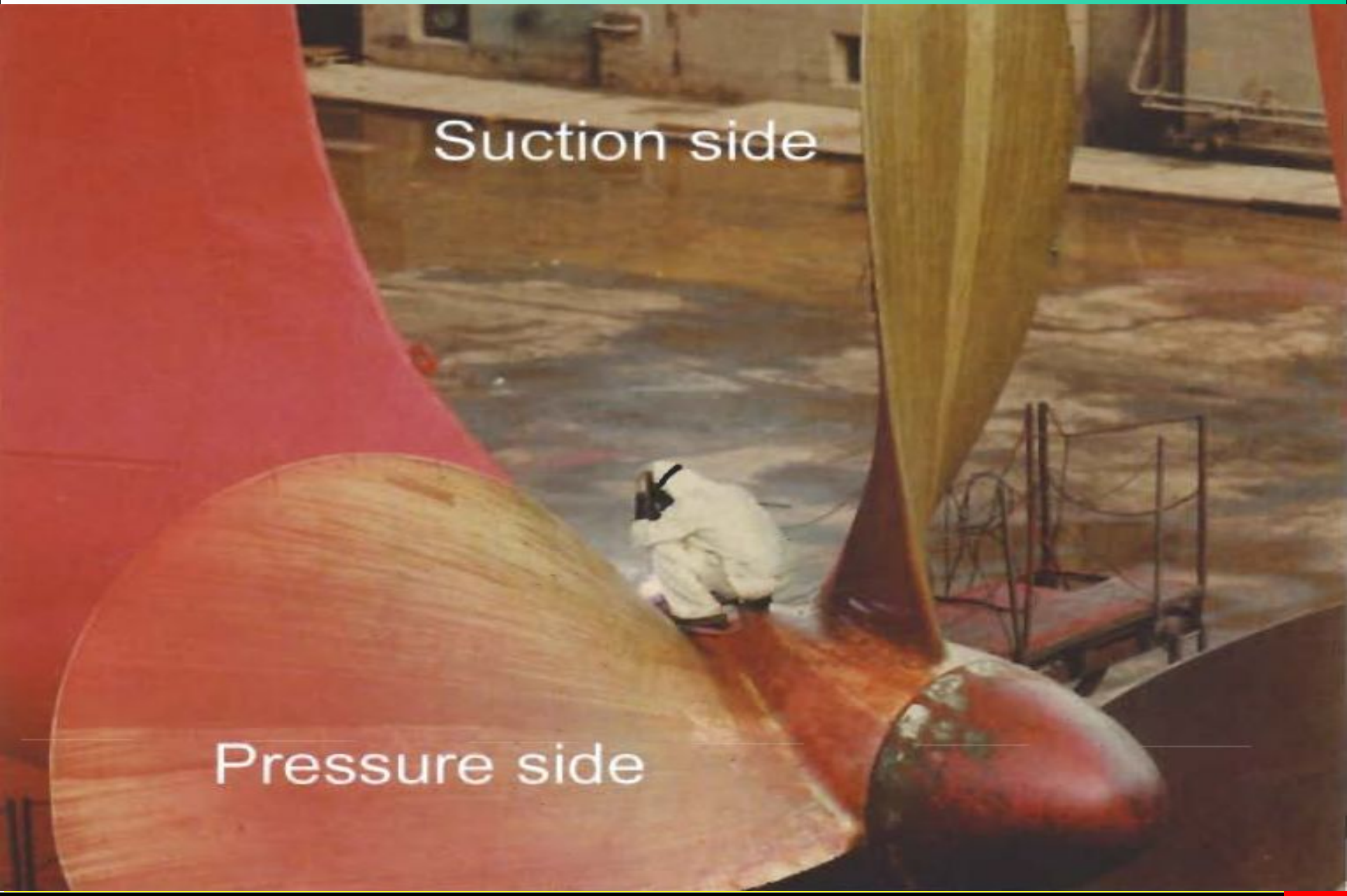


- Leading Edge: When the propeller rotating the edge piercing water is called leading edge.
- Кромка, первой входящая в воду, называется входящей

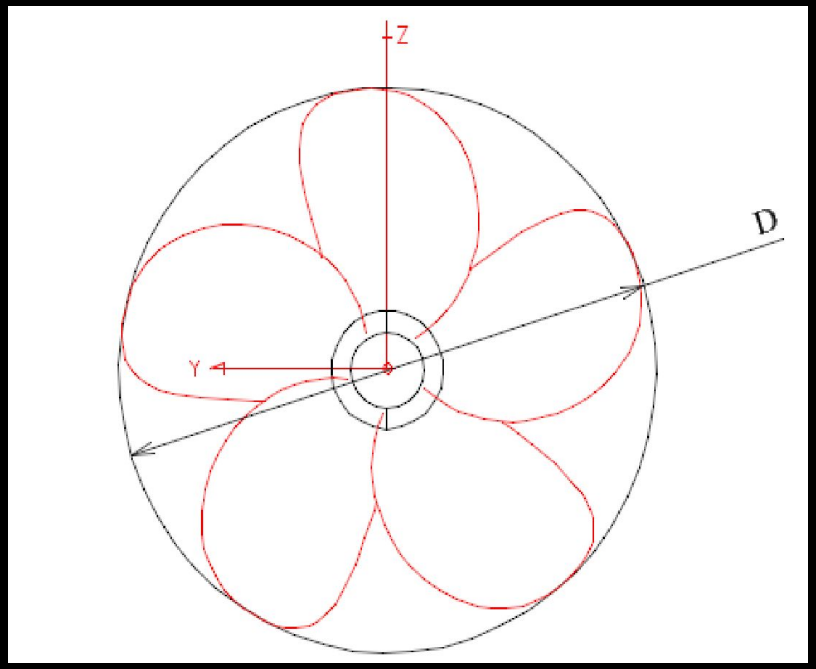


- Trailing Edge: When the propeller rotating the edge trailing the leading edge is called trailing edge.
- Выходящая кромка!

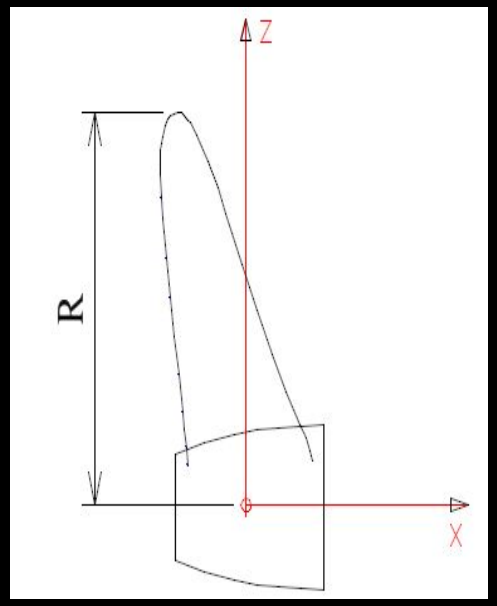



Suction side
Pressure side

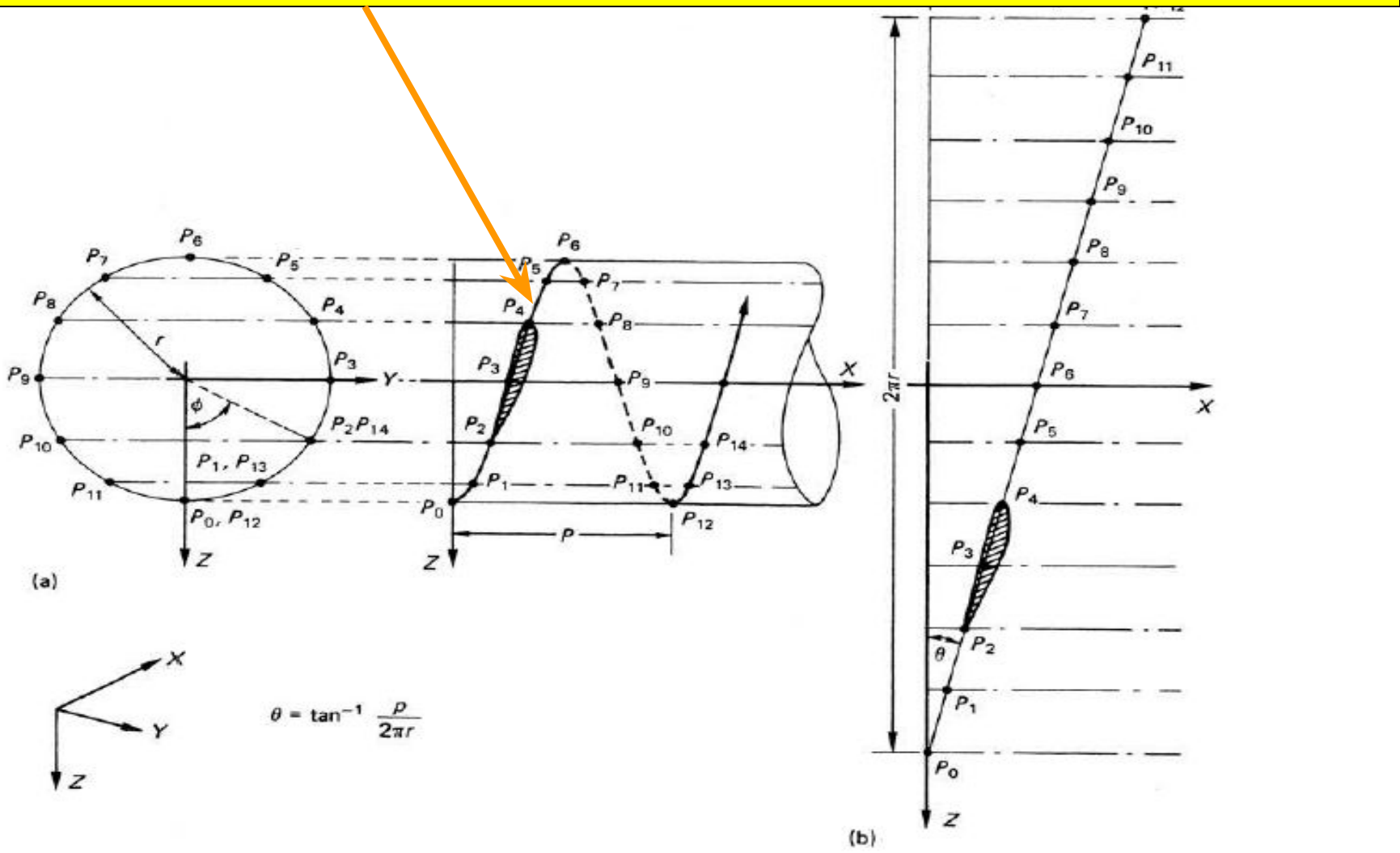
Propeller disk, looking forward
(Диск винта)



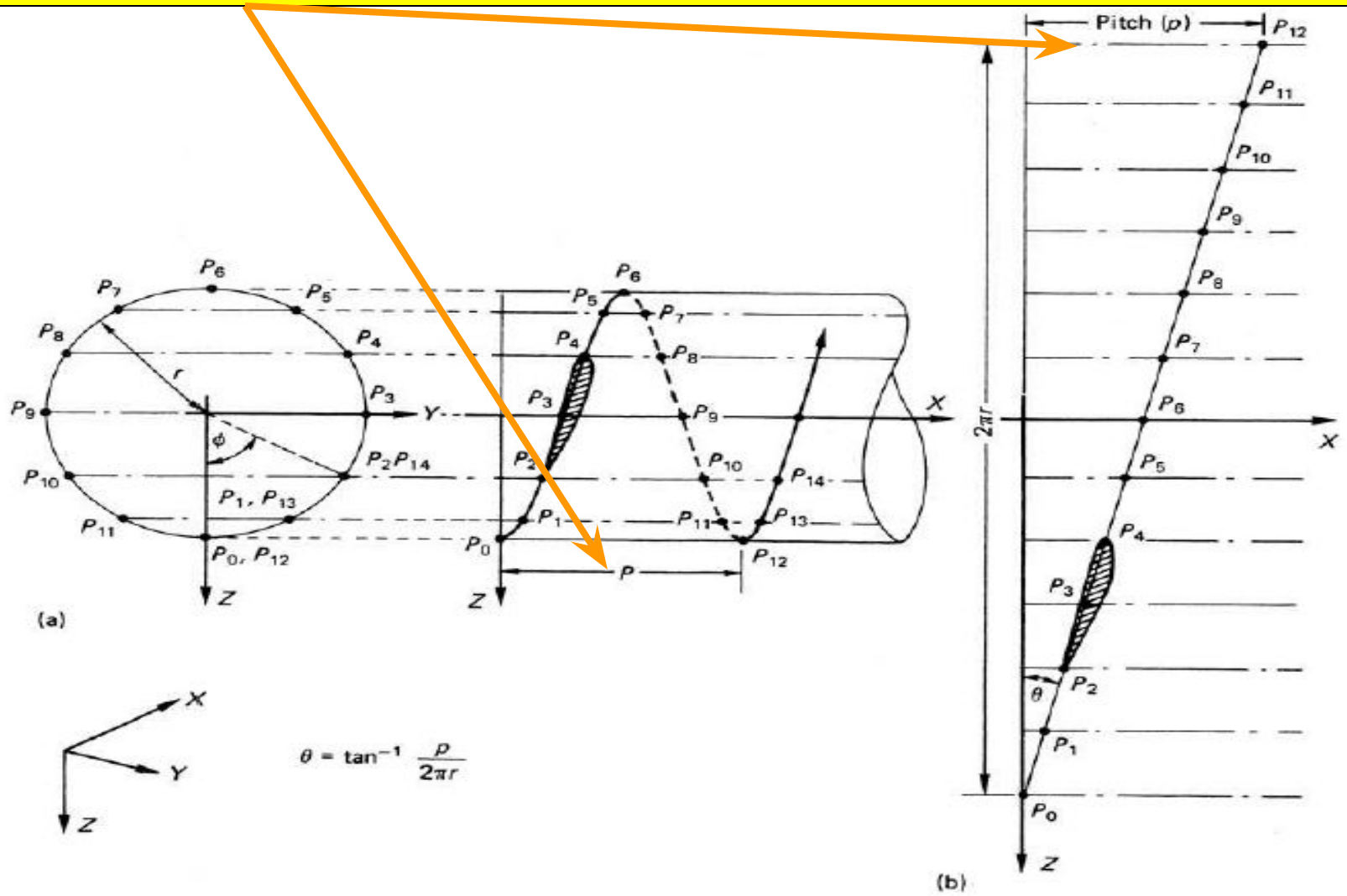
Propeller radius
Радиус винта



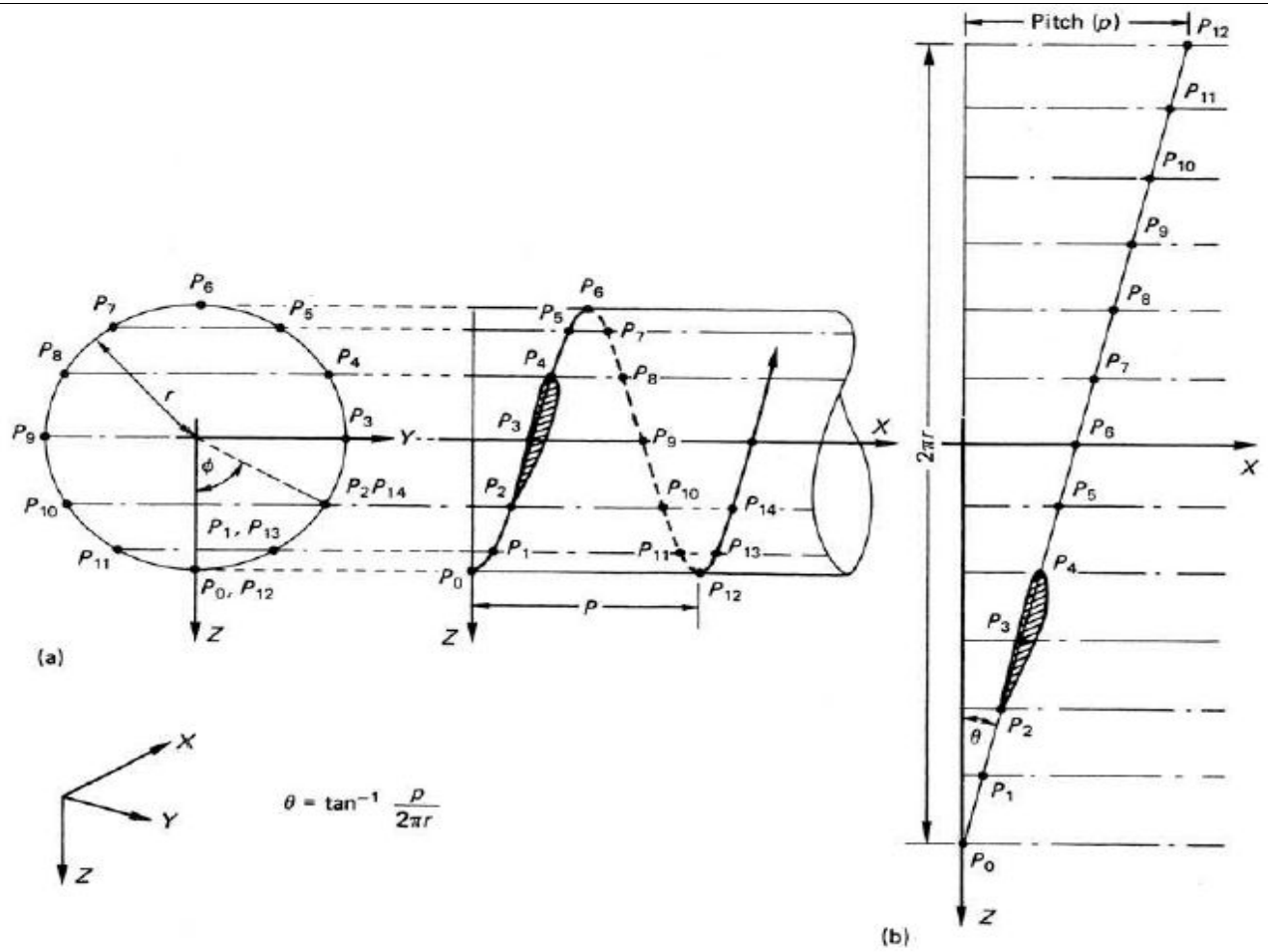
- Если точка P, лежащая на поверхности цилиндра радиуса r начнет одновременно двигаться вдоль оси X от начальной точки P_0 и вращаться вокруг этой оси, то получим цилиндрическую спираль.



- **Шагом винтовой линии P (Pitch) называют продольное перемещение точки за один оборот (360 градусов).**

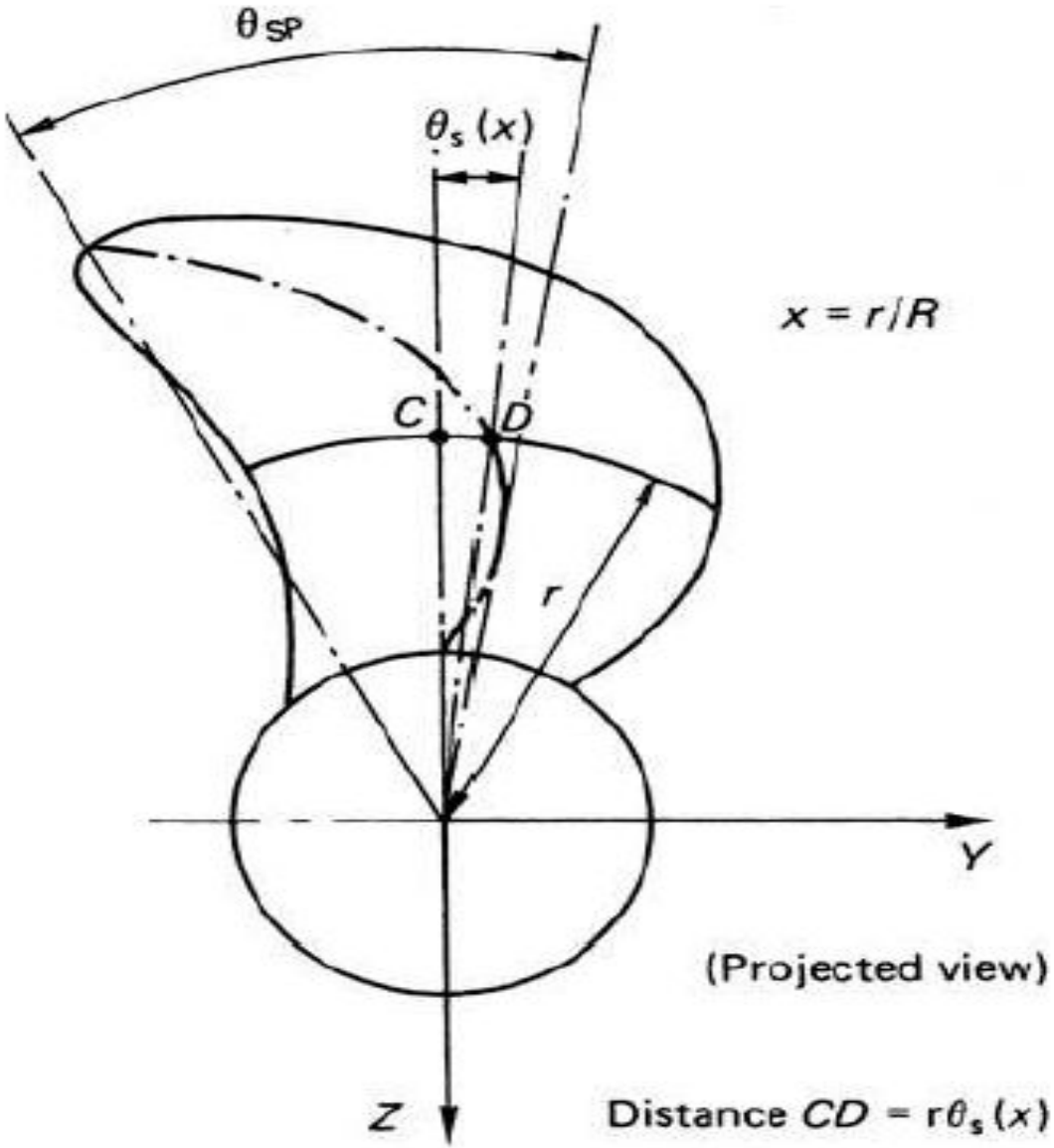


- **Шаговый угол:**
- **The distance moved forward by the helical line during this revolution is P and the helix angle is given by:**

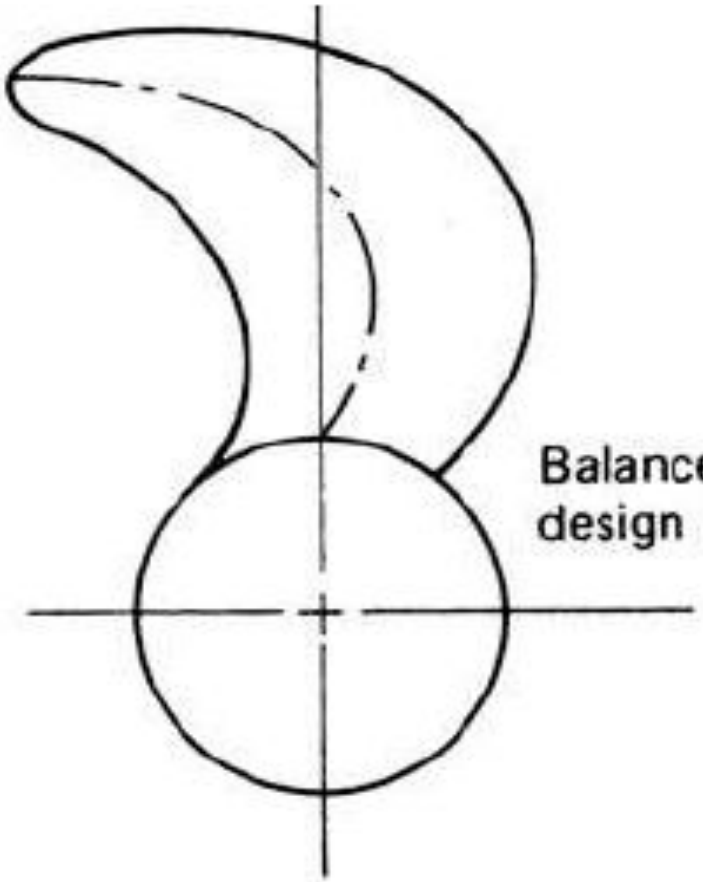


$$\theta = \tan^{-1}\left(\frac{p}{2\pi r}\right)$$

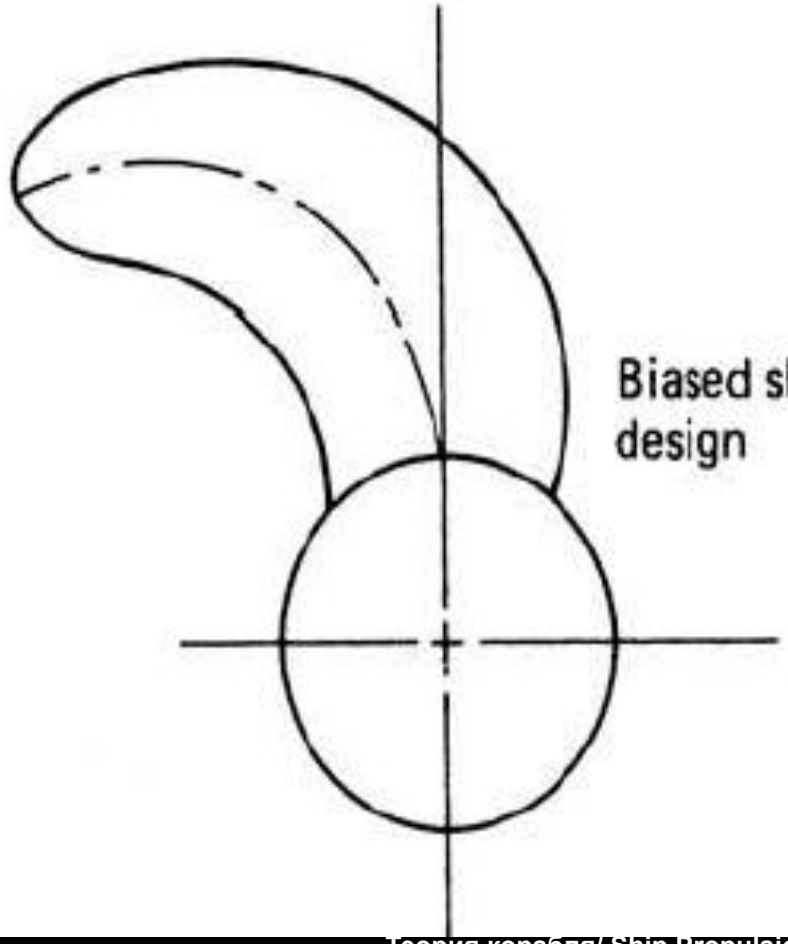
- Skew/ САБЛЕВИДНОСТЬ
- It is the angle between the mid-chord position of a section and the directrix (θs).
- The propeller skew angle (θsp) is defined as the greatest angle measured at the shaft centre line which can be drawn between lines passing from the shaft centreline through the mid chord position of any two sections.



- Саблевидность бывает двух типов:
- i- Сбалансированная: Directrix пересекает среднюю линию дважды.
- ii- Biased skew (Со скосом): Directrix пересекает среднюю линию однажды или не пересекает вообще



Balanced skew design



Biased skew design

Саблевидные гребные винты

Лопасти разной саблевидности

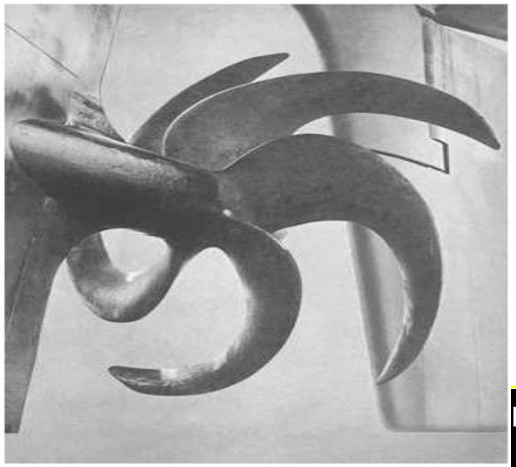
DDG51

Преимущества

- Уменьшение взаимодействия между винтом и рулем.
-Уменьшение шума, пульсаций давления и вибрации

Недостатки

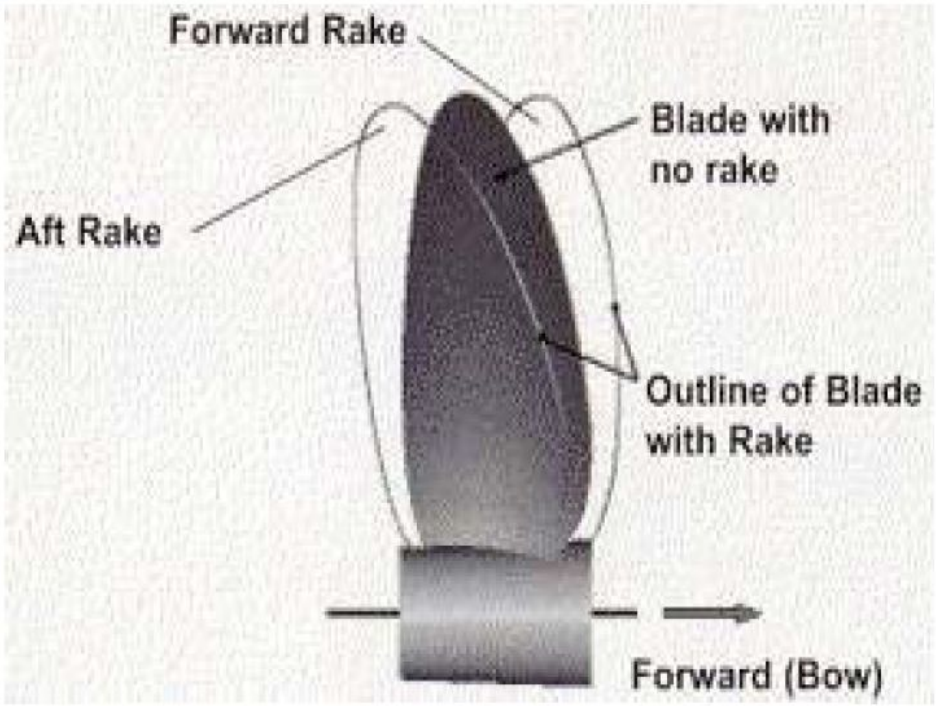
- Дорогие!
- Менее эффективны
-при реверсе

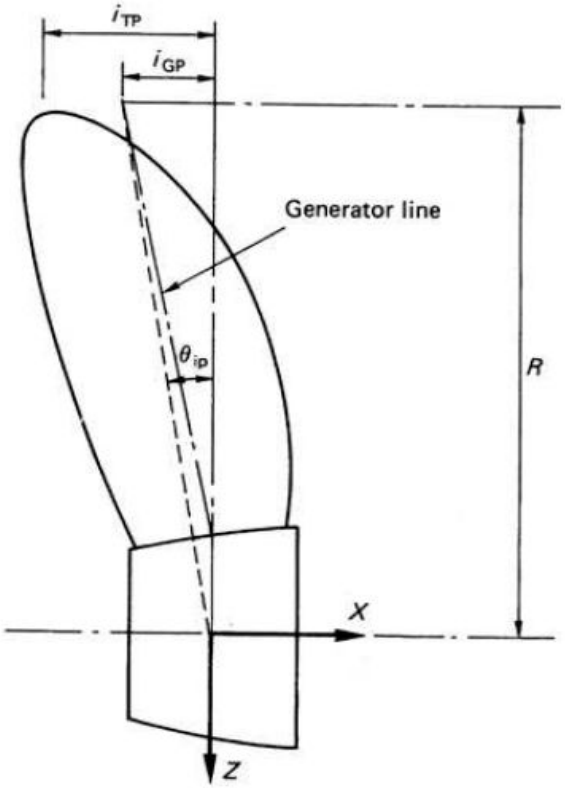


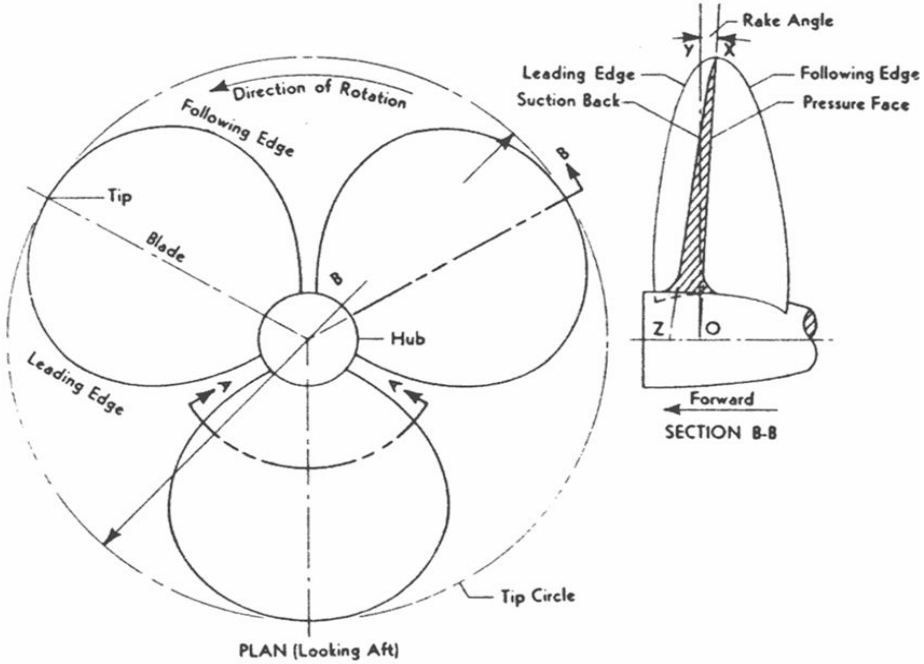
- The displacement from the propeller plane to the generator line in the direction of the shaft axis is called **rake (Наклон лопасти)**. The propeller rake is divided into two components: generator line rake and skew induced rake.

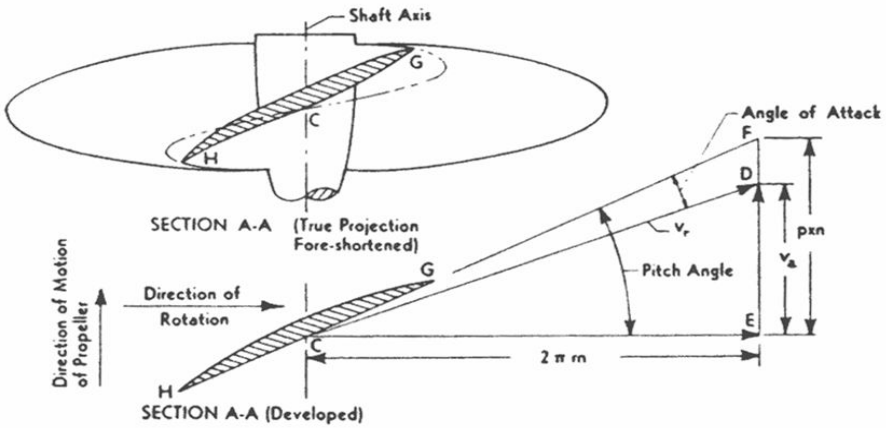
$$i_T(r) = i_G(r) + i_s(r)$$

$$i_s(r) = r\theta_s \tan(\theta_{nt})$$

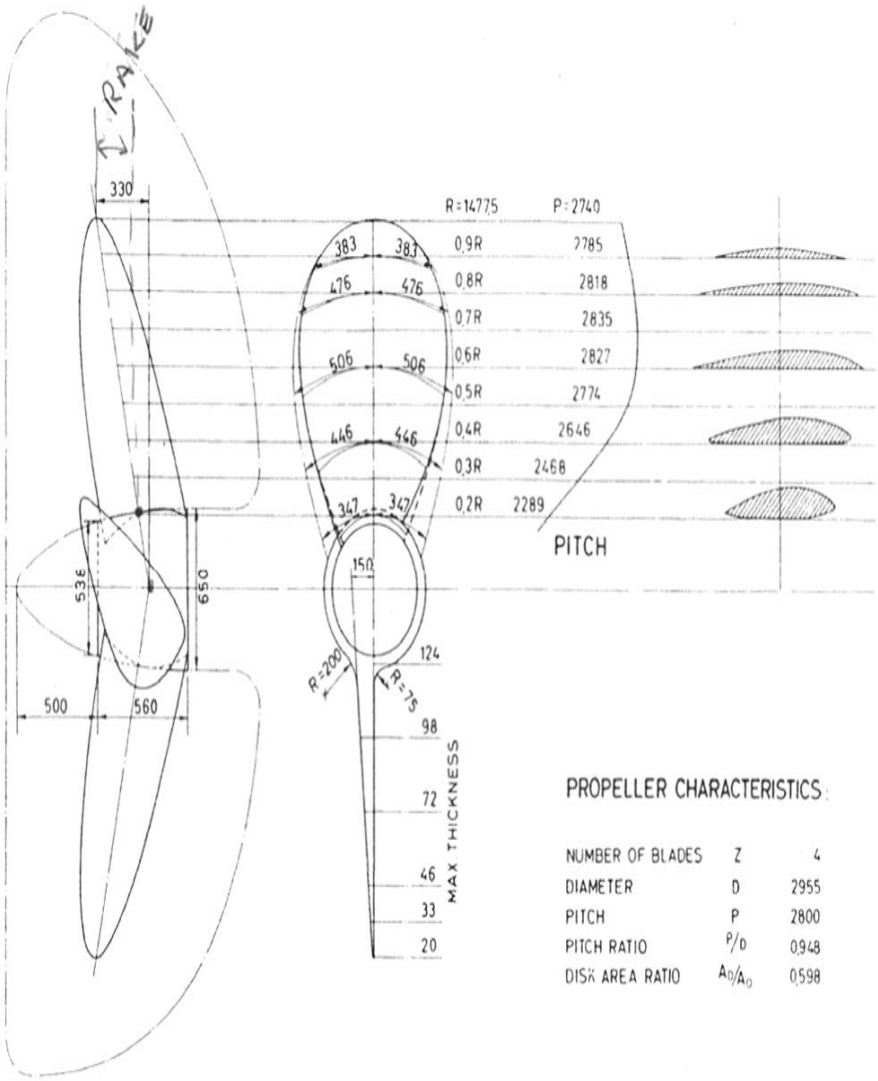






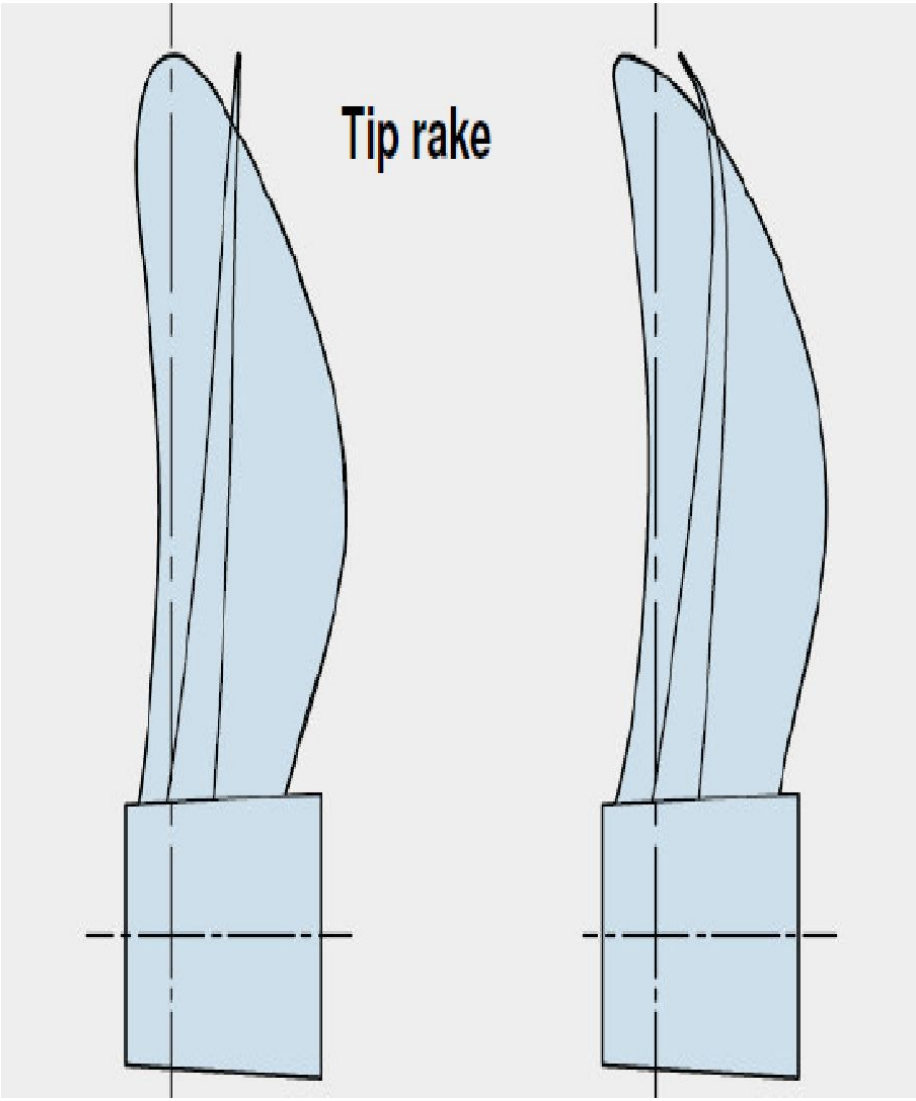


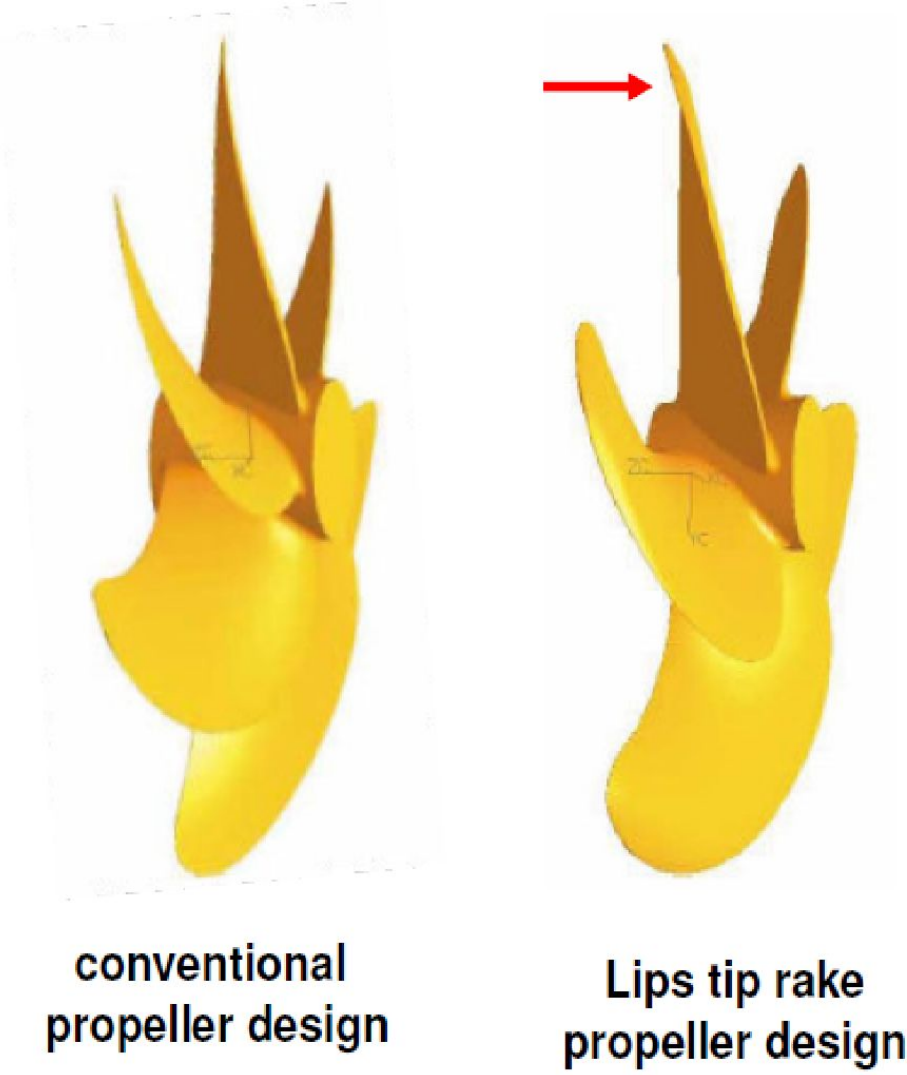
Propeller definition diagram (three-bladed, right-hand, constant-pitch propeller)



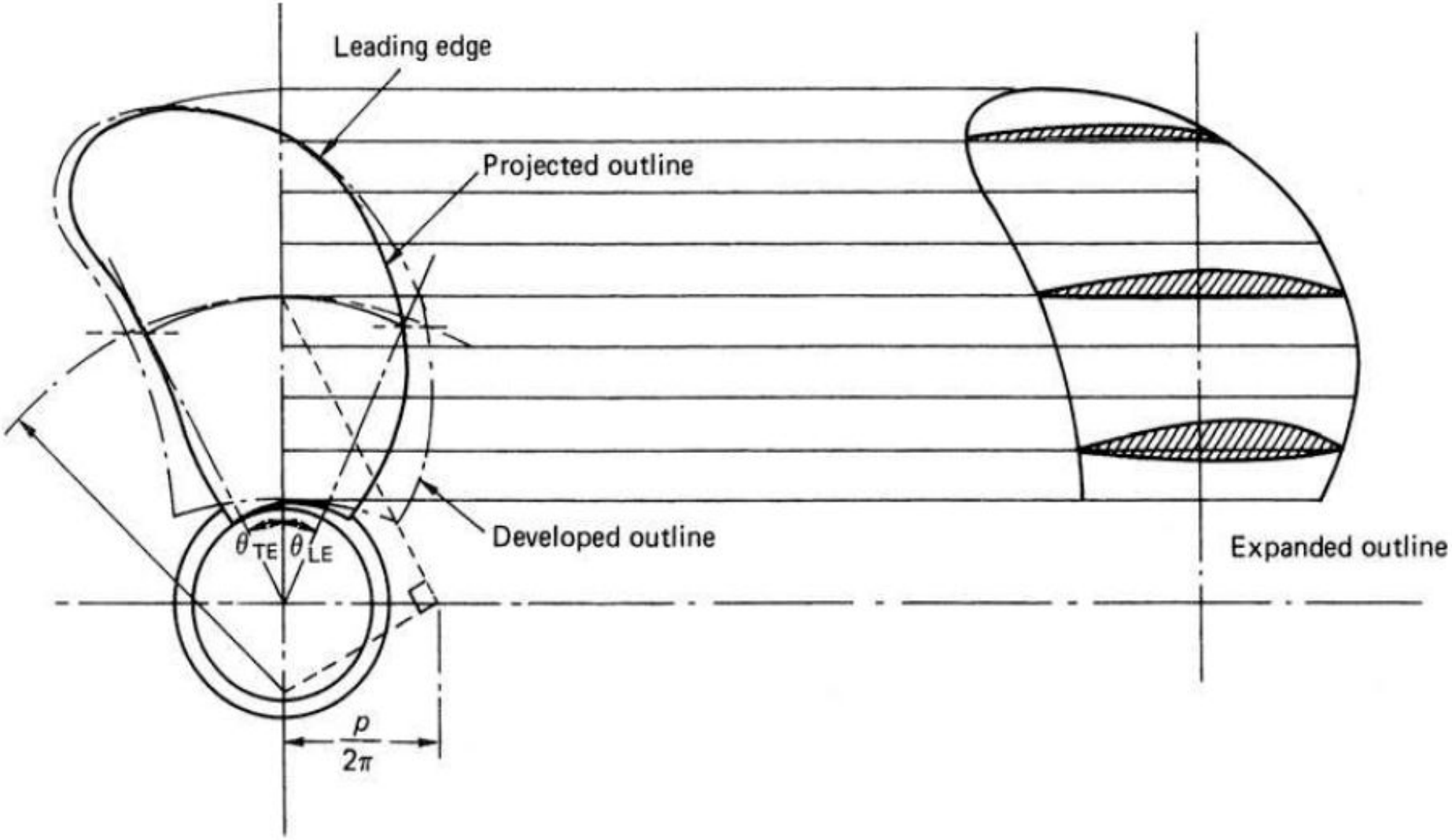
Propeller Geometry Definitions

Загиб края лопасти





• Контуры и площади



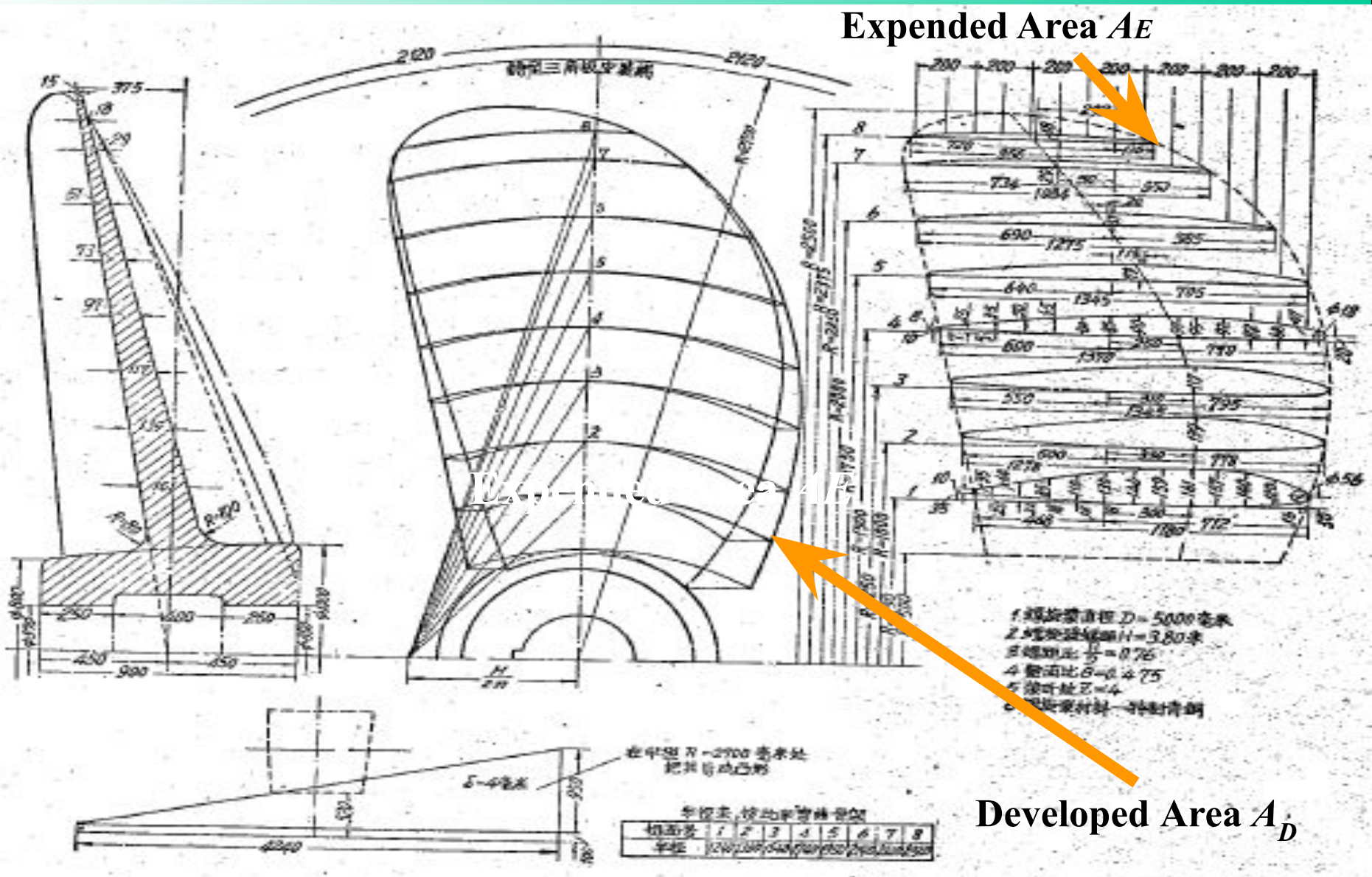


图 3-21

- **Для описания винта используют пять контуров и соответствующих площадей:**
- 1. Disc outline (area) **(A_0)** **Диск винта (площадь)**
- 2. Projected outline **(A_p)** **Нормальная проекция**
- 3. Developed outline **(A_D)** **Развернутая проекция (используется редко)**
- 4. Expanded outline **(A_E)** **Спрямленная поверхность**
- 5. Swept outline **(A_S)** **Ометаемая поверхность (диск винта за исключением проекции ступицы)**

Построение развернутой проекции вручную

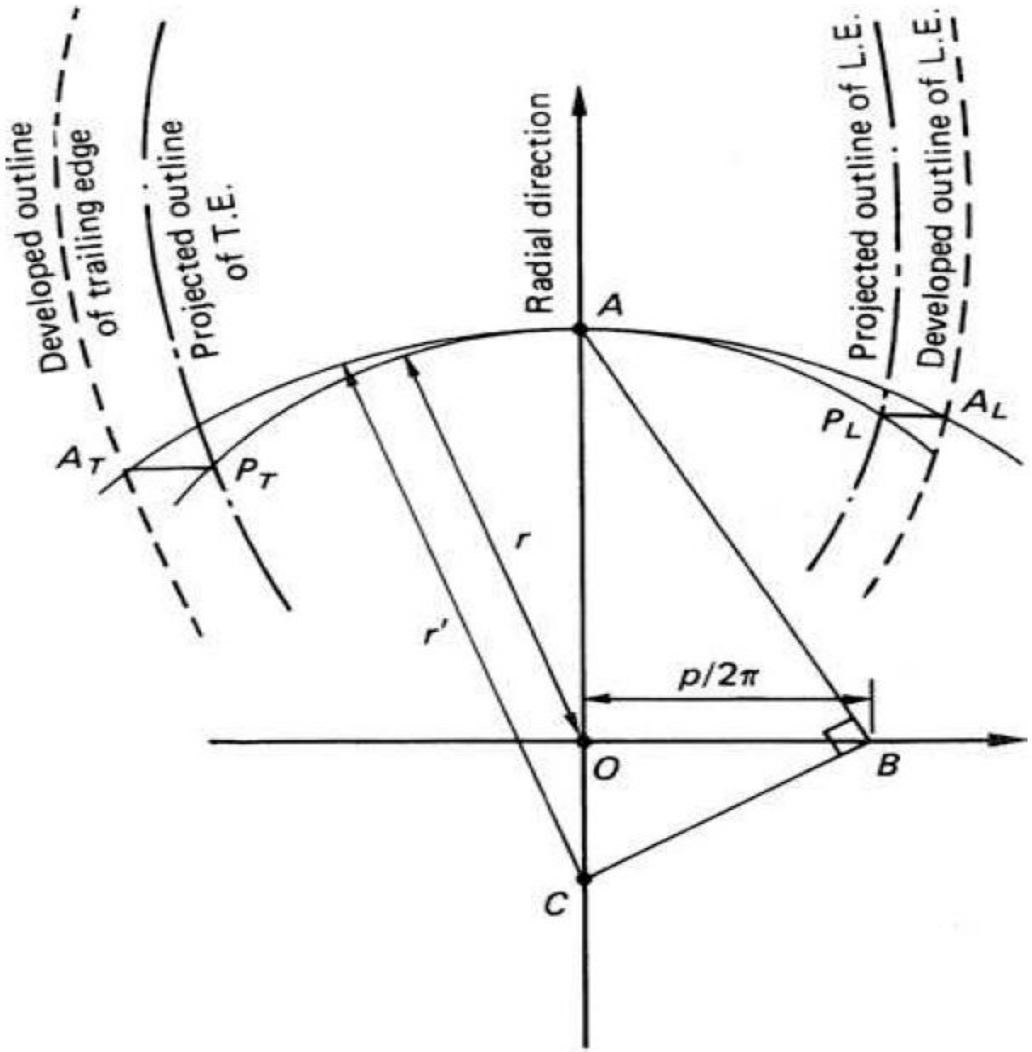
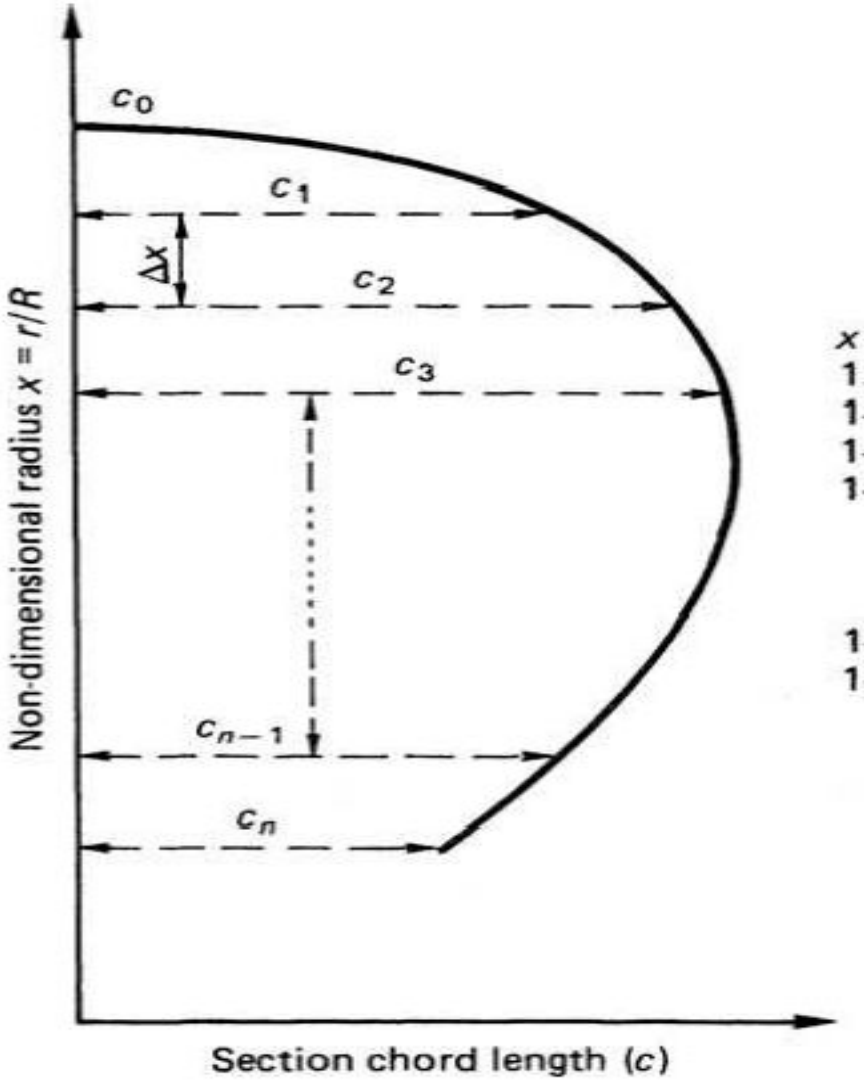


Figure 3.14 Holst's propeller drawing method

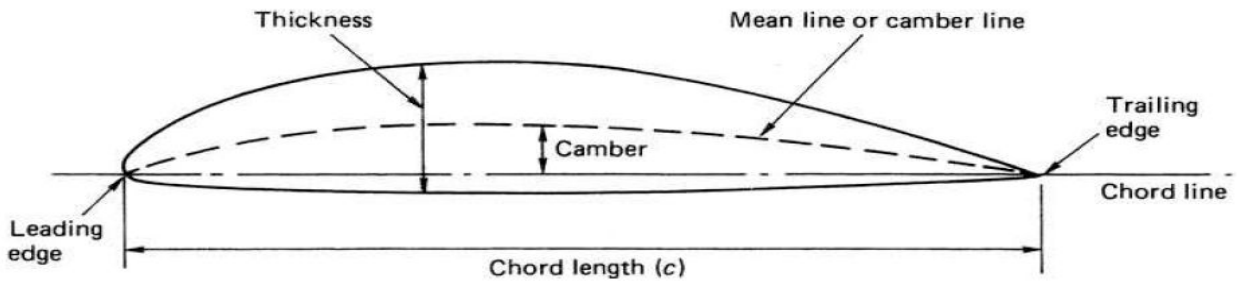
ВЫЧИСЛЕНИЕ ПЛОЩАДИ AE

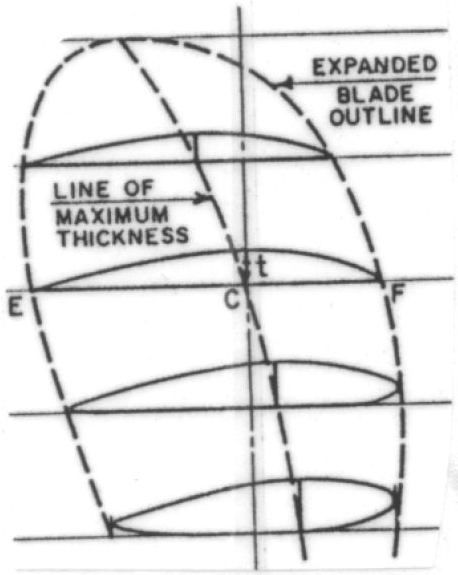


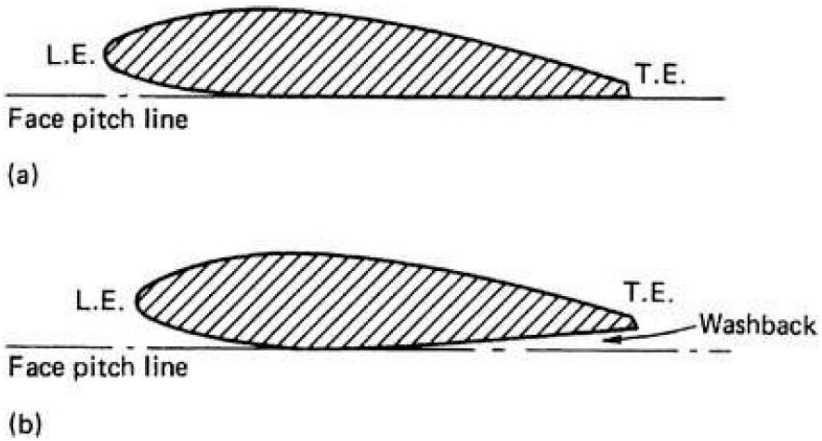
x	c	SM	c.SM
1.00	c_0	1/2	$c_0/2$
$1-\Delta x$	c_1	2	$2c_1$
$1-2\Delta x$	c_2	1	c_2
$1-3\Delta x$	c_3	2	$2c_3$
.	.	.	.
.	.	.	.
.	.	.	.
$1-(n-1)\Delta x$	c_{n-1}	2	$2c_{n-1}$
$1-n\Delta x$	c_n	1/2	$c_n/2$
			$\Sigma(c.SM)$

$$A_E \simeq 0.667z\ \Delta x\ \Sigma(c.SM)$$

Построение профилей





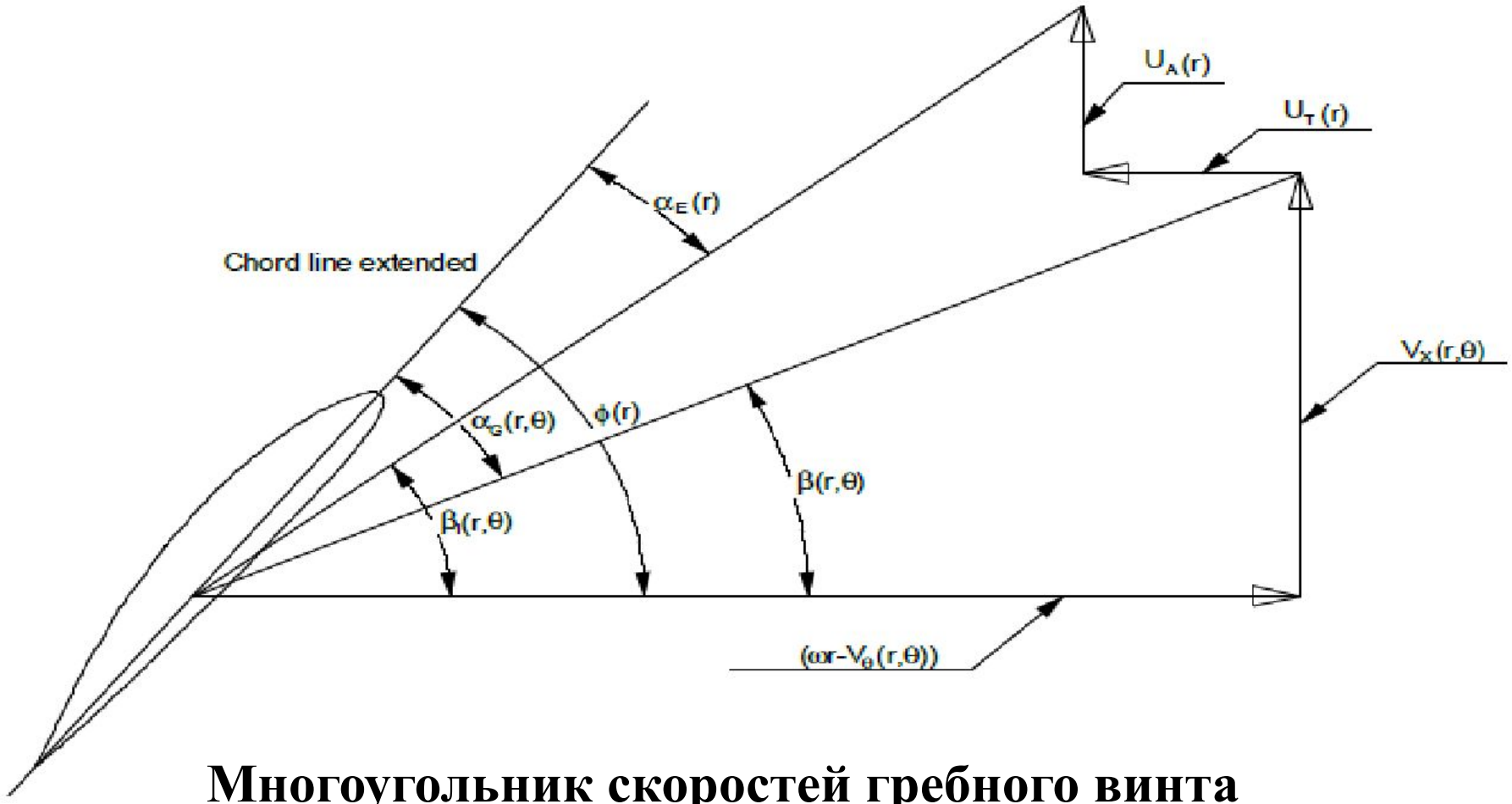


Propeller series СЕРИИ ГРЕБНЫХ ВИНТОВ

Table 6.3 Fixed pitch, non-ducted propeller series summary

Series	*Number of propellers in series*	*Range of parameters*			*D (mm)*	r_h/R	*Cavitation data available*	*Notes*
		Z	A_E/A_O	P/D				
Wageningen B-series	≃120	2–7	0.3–1.05	0.6–1.4	250	0.169	No	Four-bladed propeller has non-constant pitch dist
Au-series	34	4–7	0.4–0.758	0.5–1.2	250	0.180	No	
Gawn-series	37	3	0.2–1.1	0.4–2.0	508	0.200	No	
KCA-series	≃30	3	0.5–1.25	0.6–2.0	406	0.200	Yes	
Ma-series	32	3 and 5	0.75–1.20	1.0–1.45	250	0.190	Yes	
Newton–Rader series	12	3	0.5–1.0	1.05–2.08	254	0.167	Yes	
KCD-series	24	3–6 (mainly 4)	0.587 Principal 0.44–0.8	0.6–1.6	406	0.200	Yes	Propellers not geosyms
Meridian series	20	6	0.45–1.05	0.4–1.2	305	0.185	Yes	Propellers not geosyms

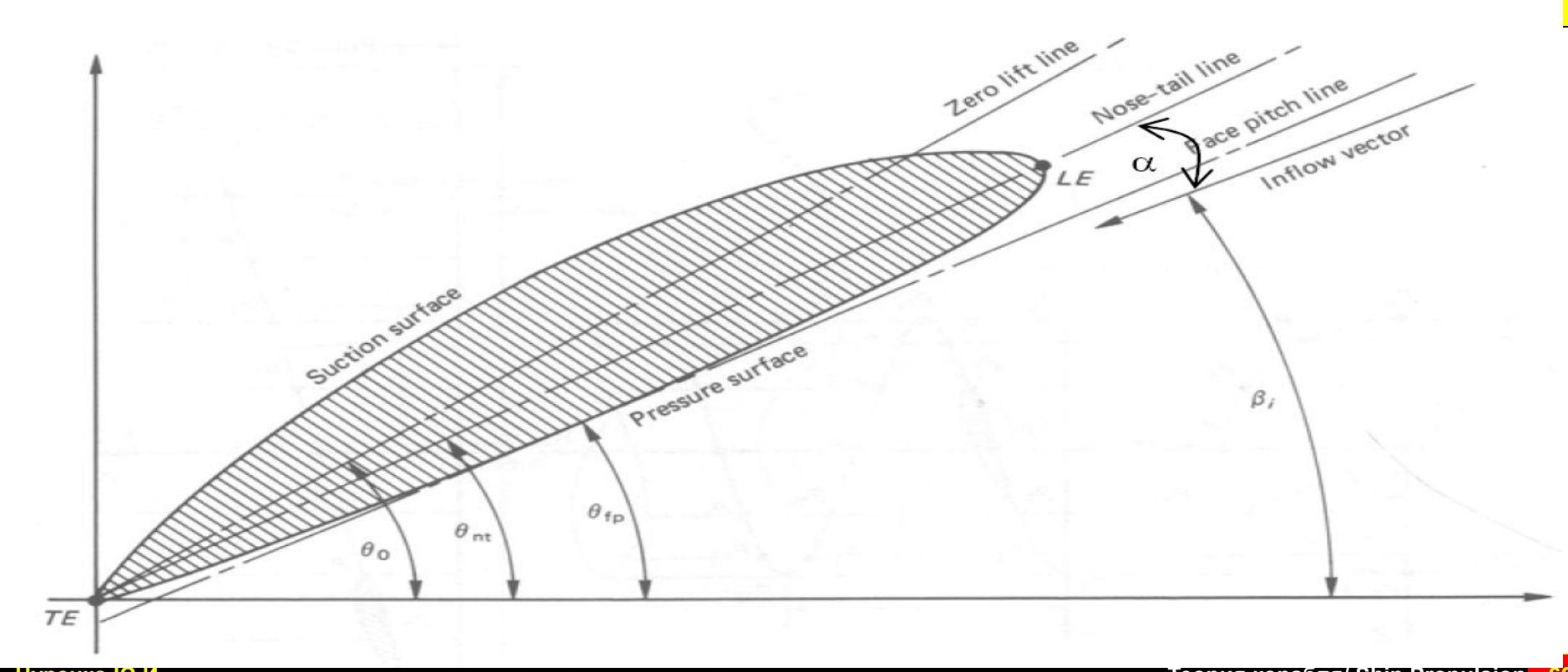
Кинематика гребного винта



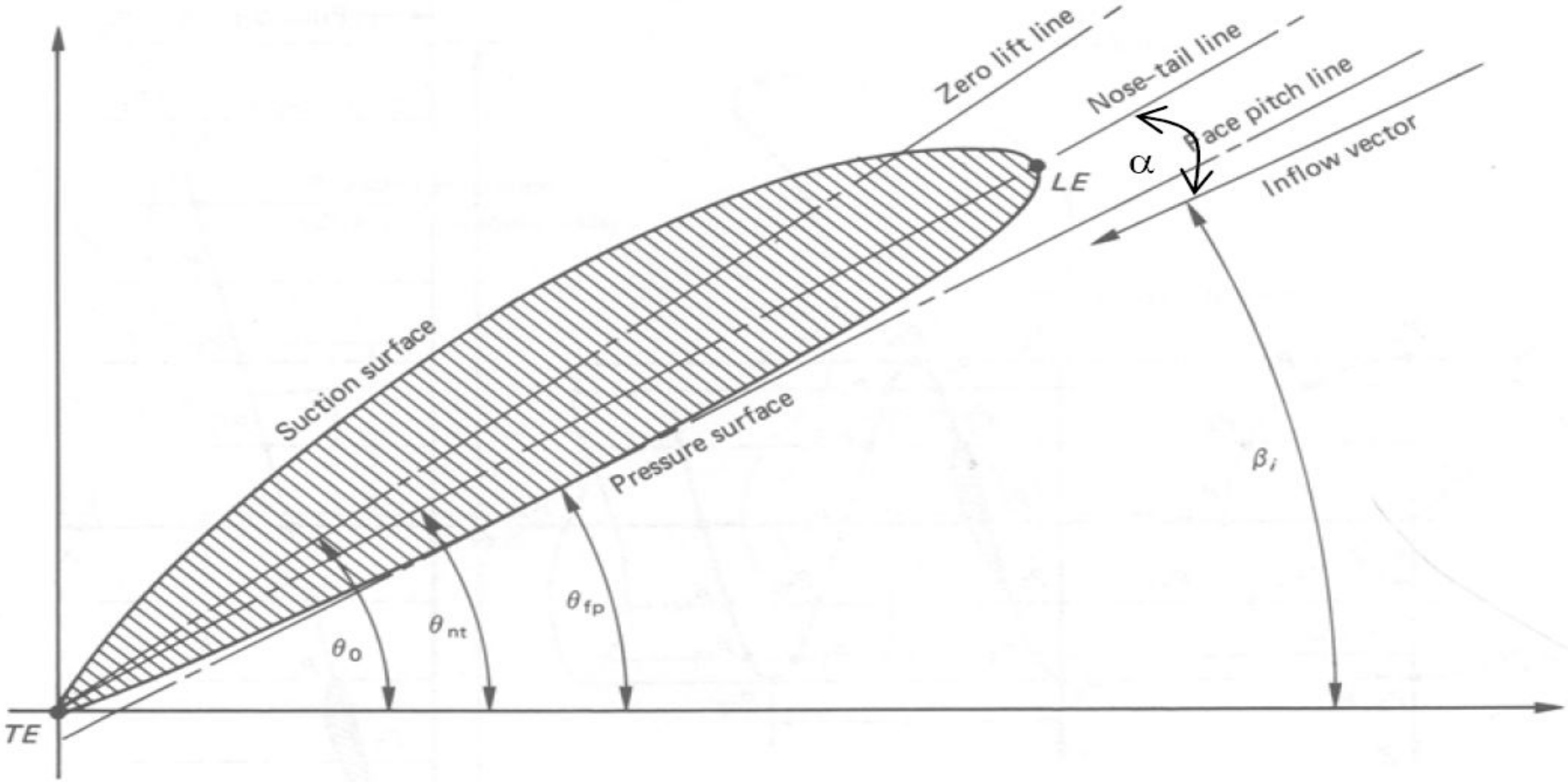
Многоугольник скоростей гребного винта

• Понятия ШАГА и ШАГОВОГО УГЛА винта:

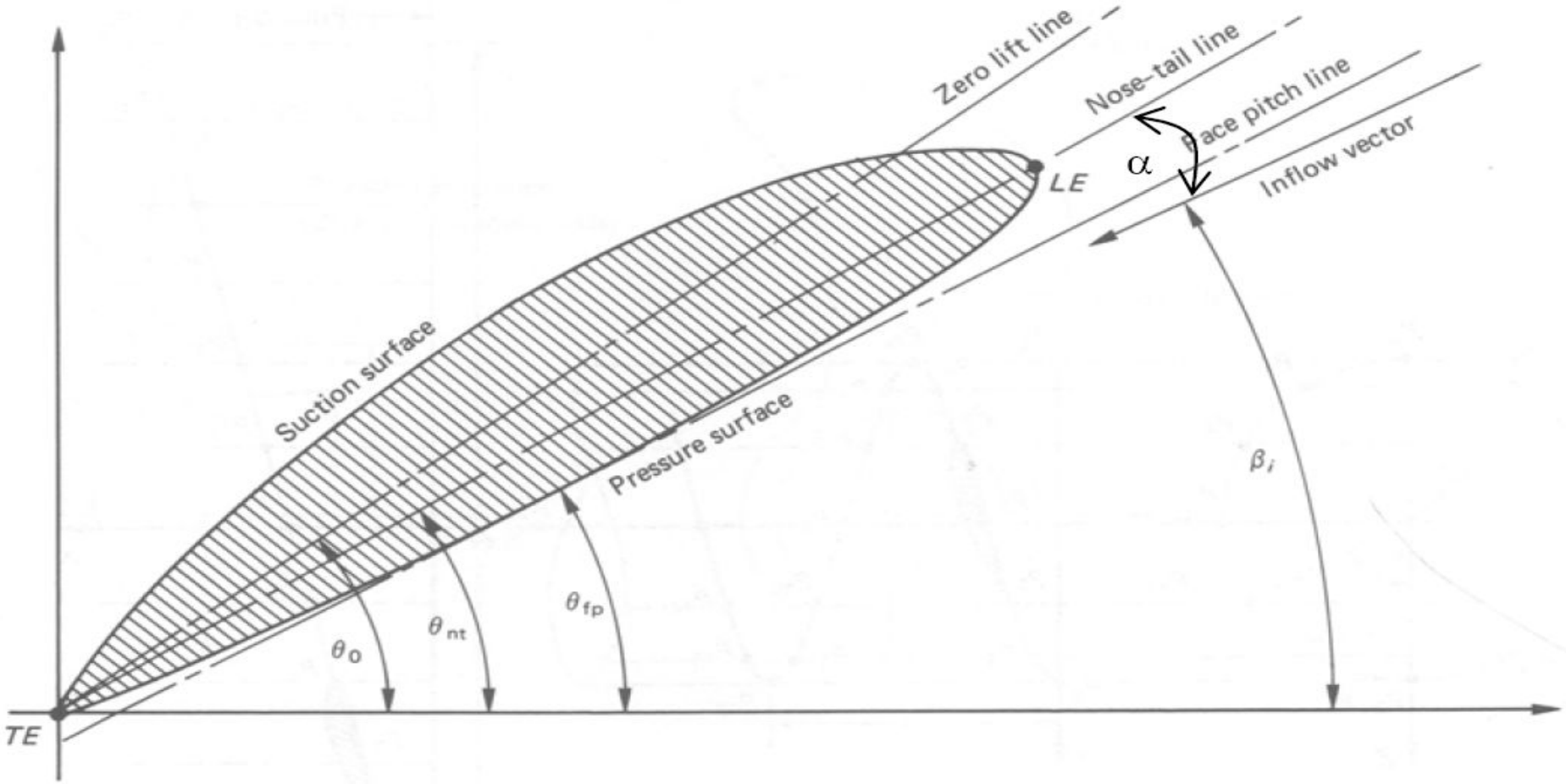
- θ_0 is the effective pitch angle of the propeller
- θ_{nt} or θ is the geometric pitch angle of the propeller
- β_i is the hydrodynamic pitch angle
- α is the angle of attack of section



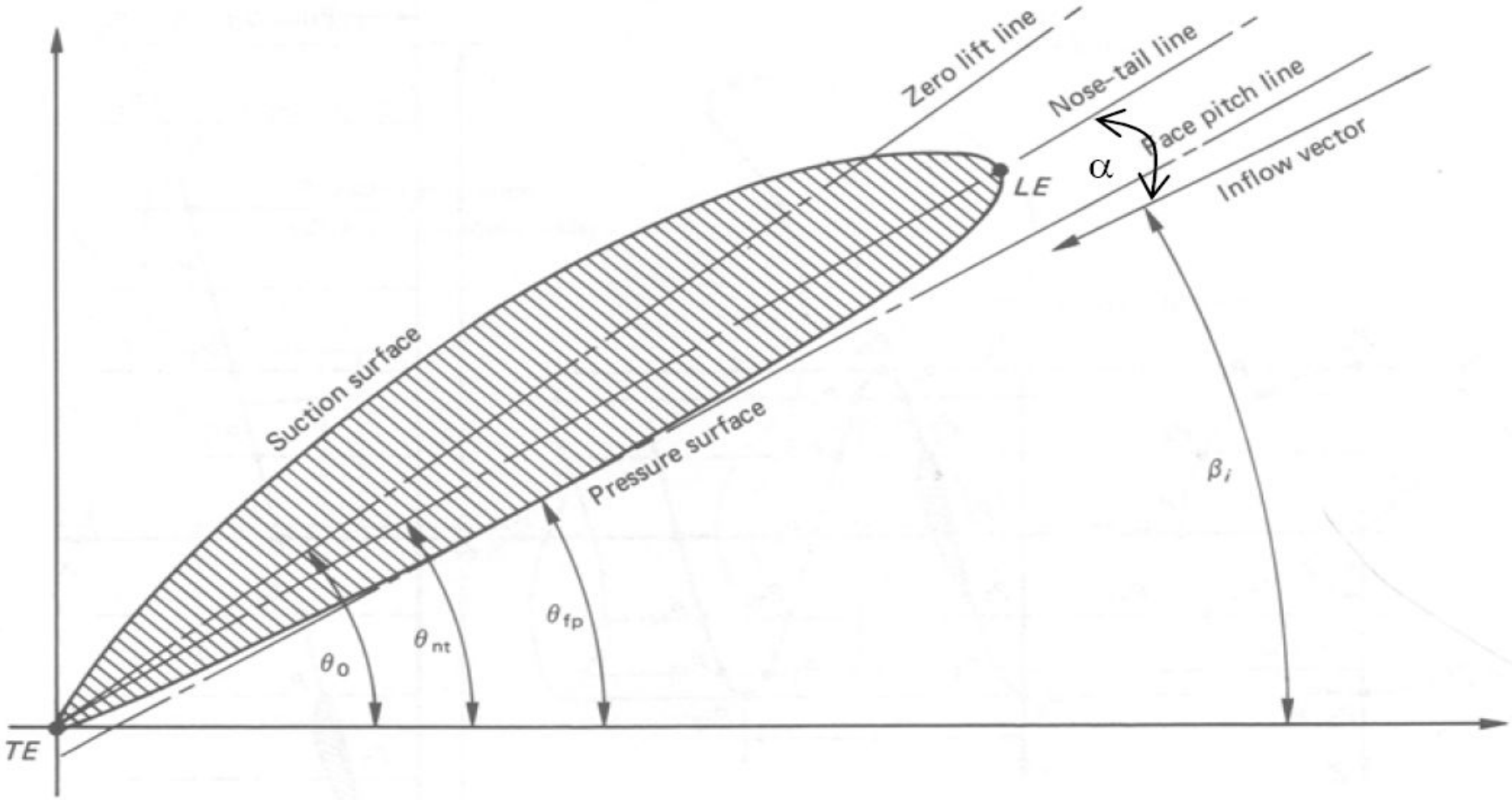
- **Nose-tail pitch: ГЕОМЕТРИЧЕСКИЙ ШАГ The straight line connecting the extremities of the mean line or nose and tail of a propeller blade is called nose-tail pitch line The section angles of attack are defined to the nose-tail line.**



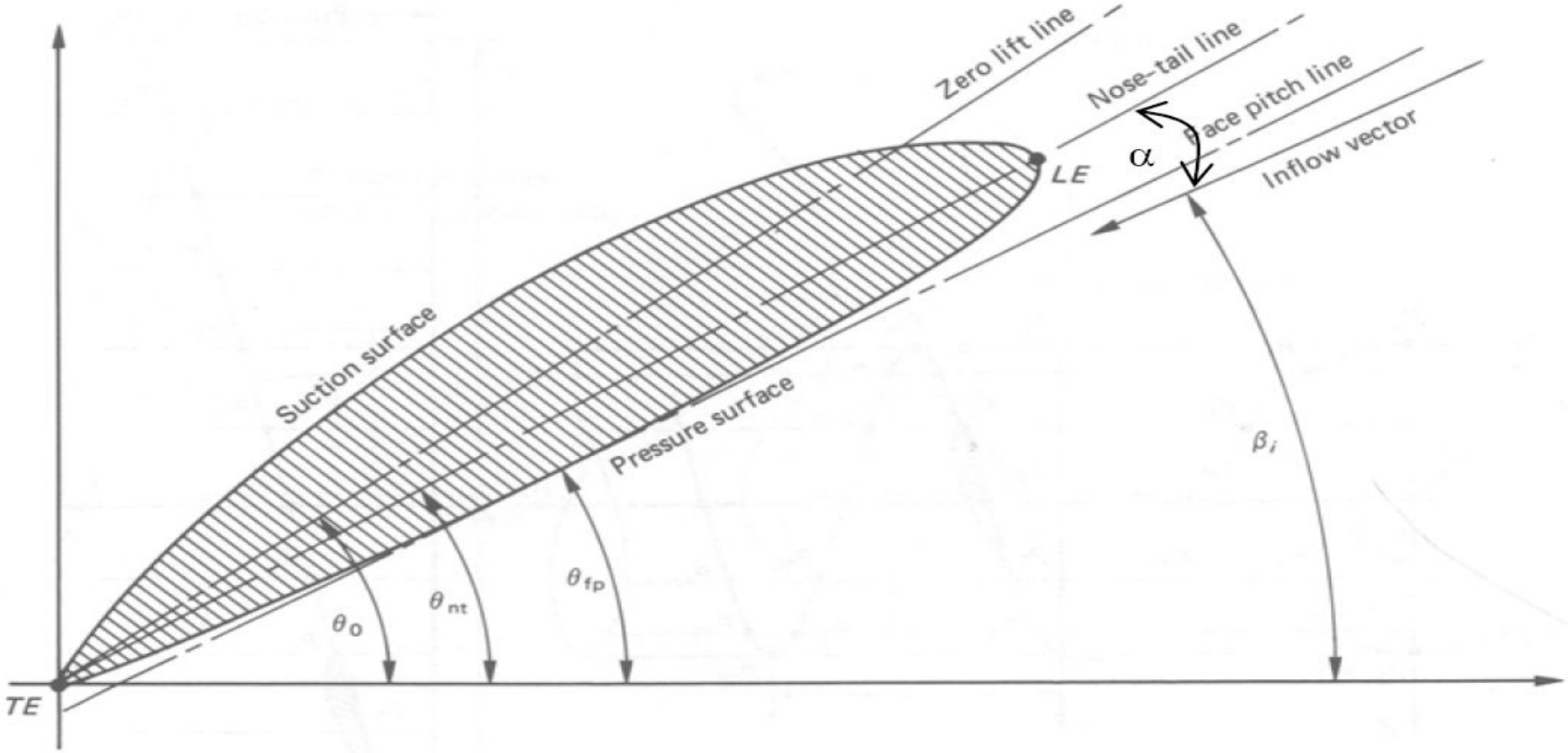
- **Face pitch: ШАГ НАГНЕТАЮЩЕЙ ПОВЕРХНОСТИ** The face pitch line is basically a tangent to section's pressure side surface and you can draw so many lines to the pressure side. Therefore its definition is not clear. It is rarely used but it can be seen in older drawings like Wageningen B series.



- **Effective or no-lift pitch: ШАГ НУЛЕВОЙ ПОДЪЁМНОЙ СИЛЫ ПРОФИЛЯ** It is the pitch line of the section corresponding to aerodynamic no-lift line which results zero lift.



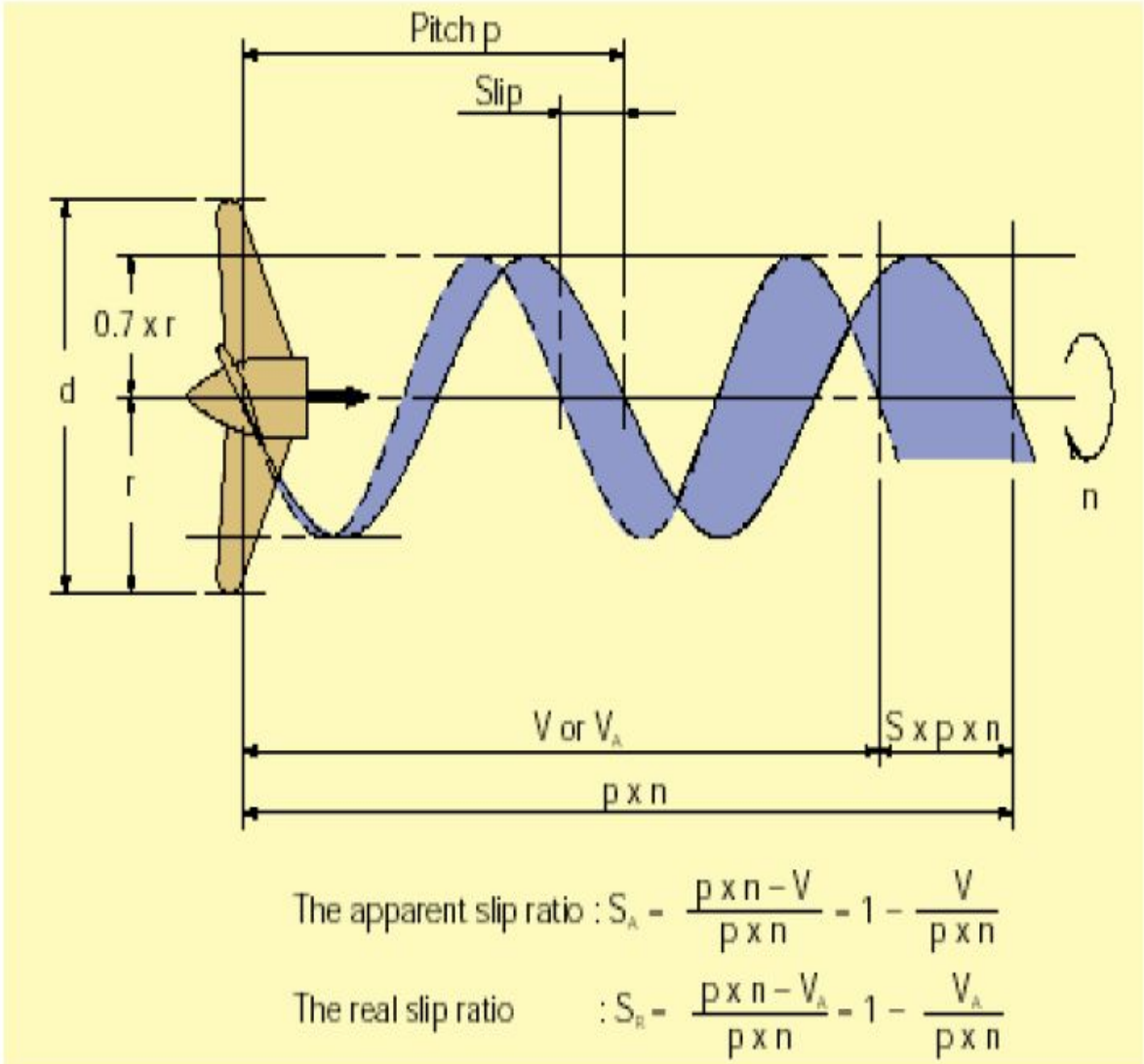
- Hydrodynamic pitch **ГИДРОДИНАМИЧЕСКИЙ ШАГ** : The hydrodynamic pitch angle (βi) is the pitch angle at which the incident flow encounters the blade section.
- Pitch values at different radii are called radial pitch distribution.

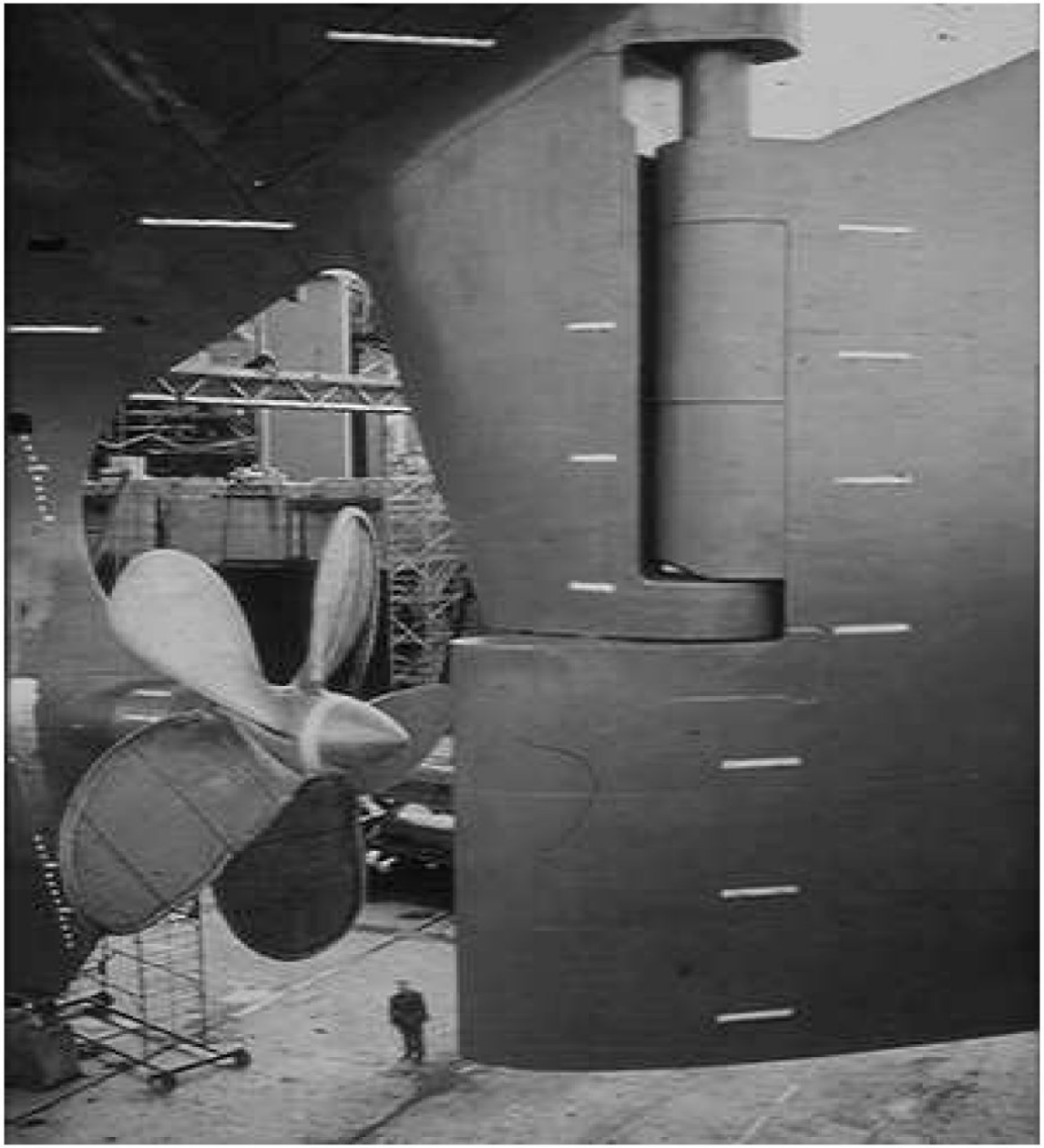


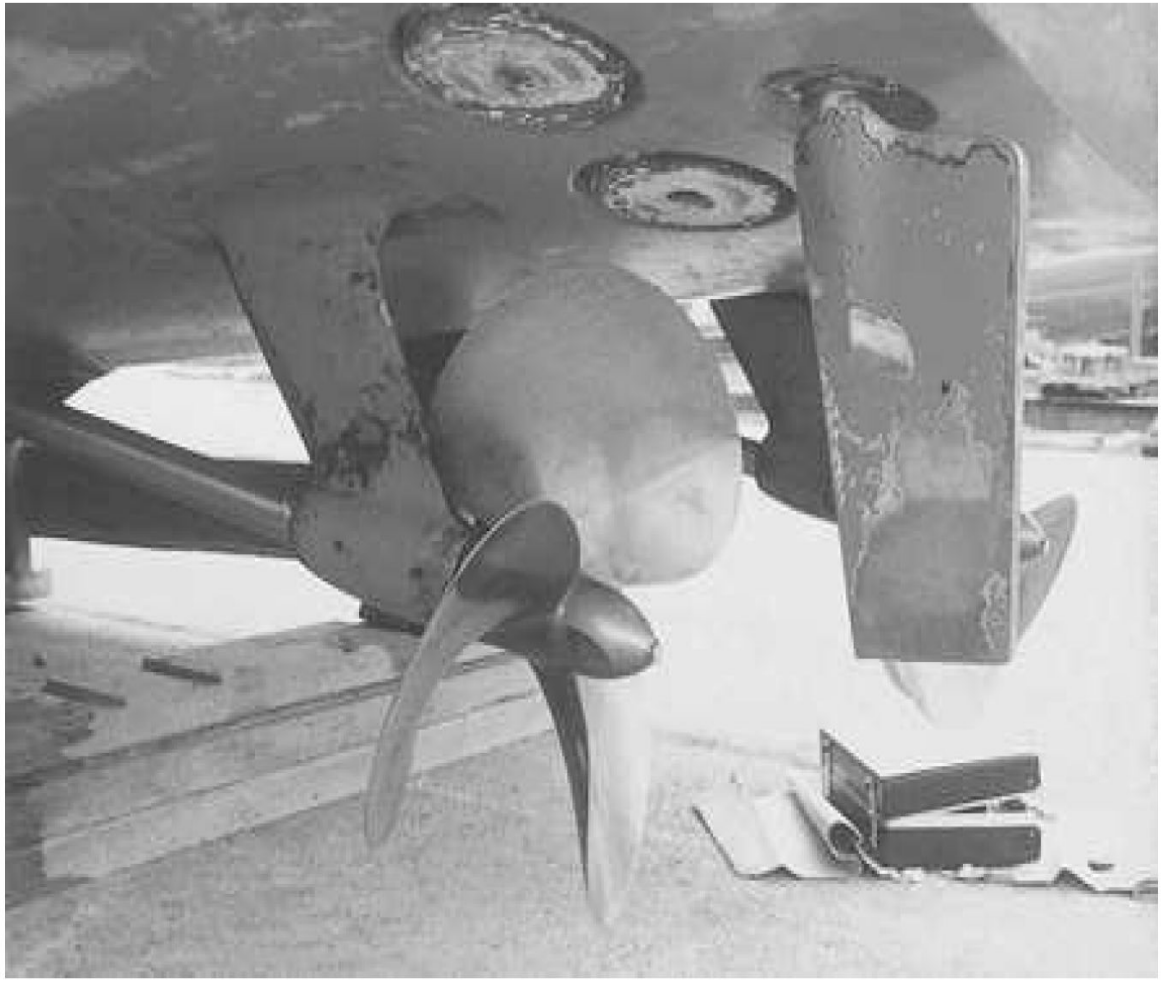
- **Slip & Slip Ratio/ Скольжение и относительное скольжение**

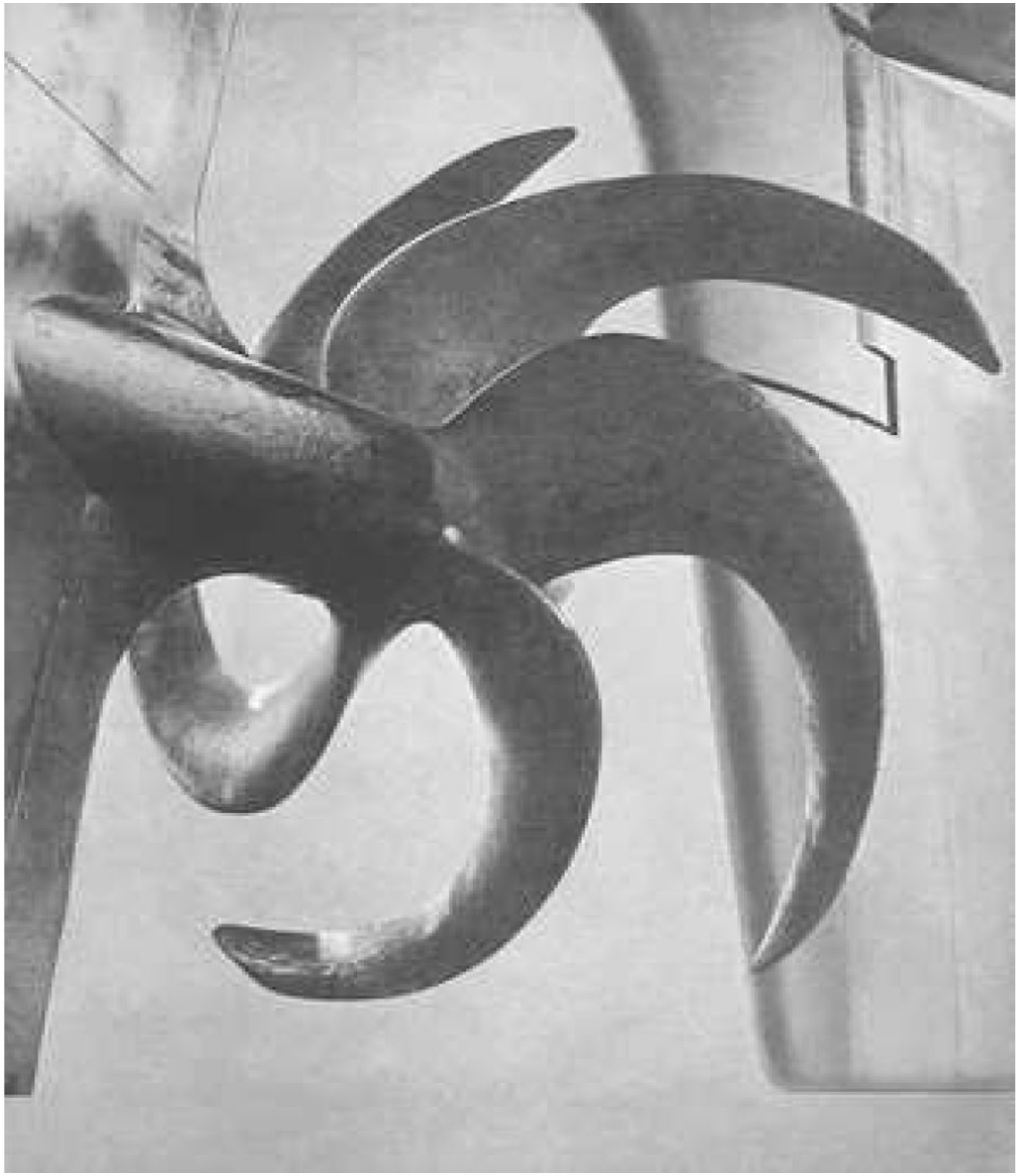
$$S_A = \frac{pn - V}{pn} = 1 - \frac{V}{pn}$$

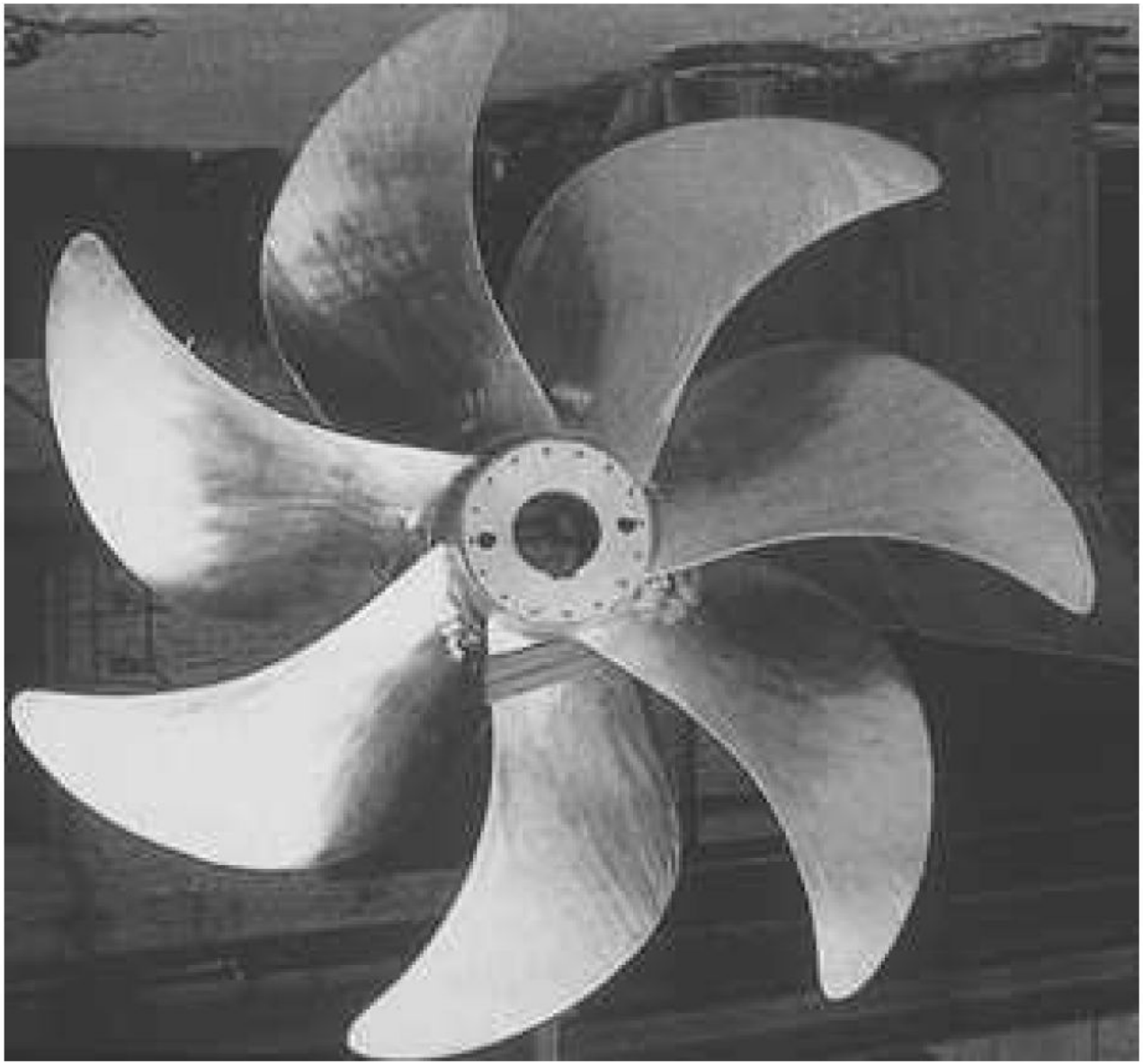
$$S_R = \frac{pn - V_A}{pn} = 1 - \frac{V_A}{pn}$$











END

ЕСТЬ ВОПРОСЫ ?