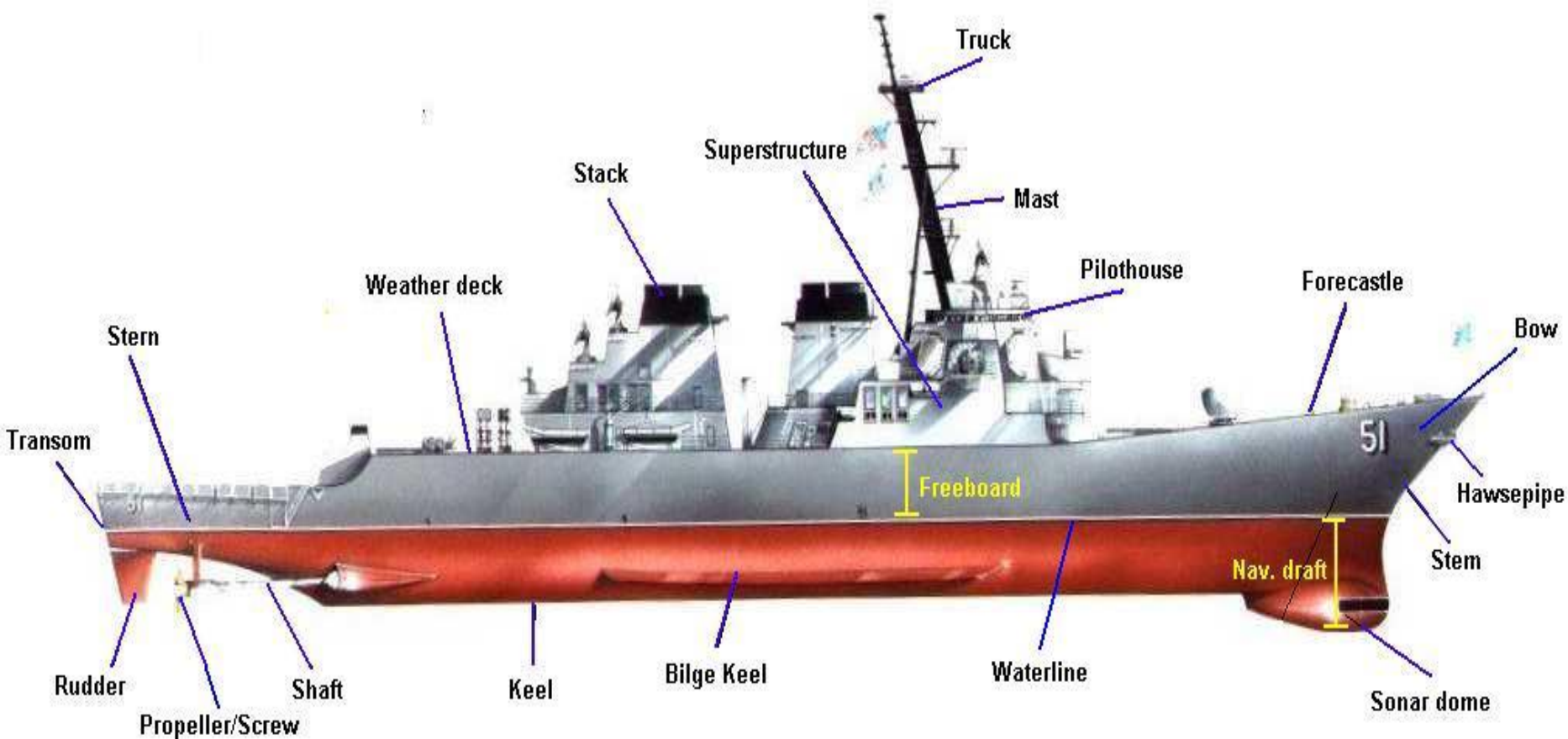


# ОСНОВНЫЕ ХАРАКТЕРИСТИКИ ГРЕБНЫХ ВИНТОВ





# Корабельная терминология



## Размещение гребных винтов

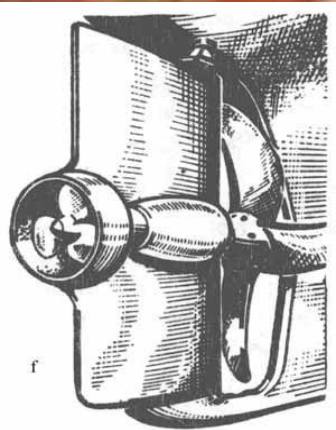


*Stern post with shafting of a controllable pitch propeller*

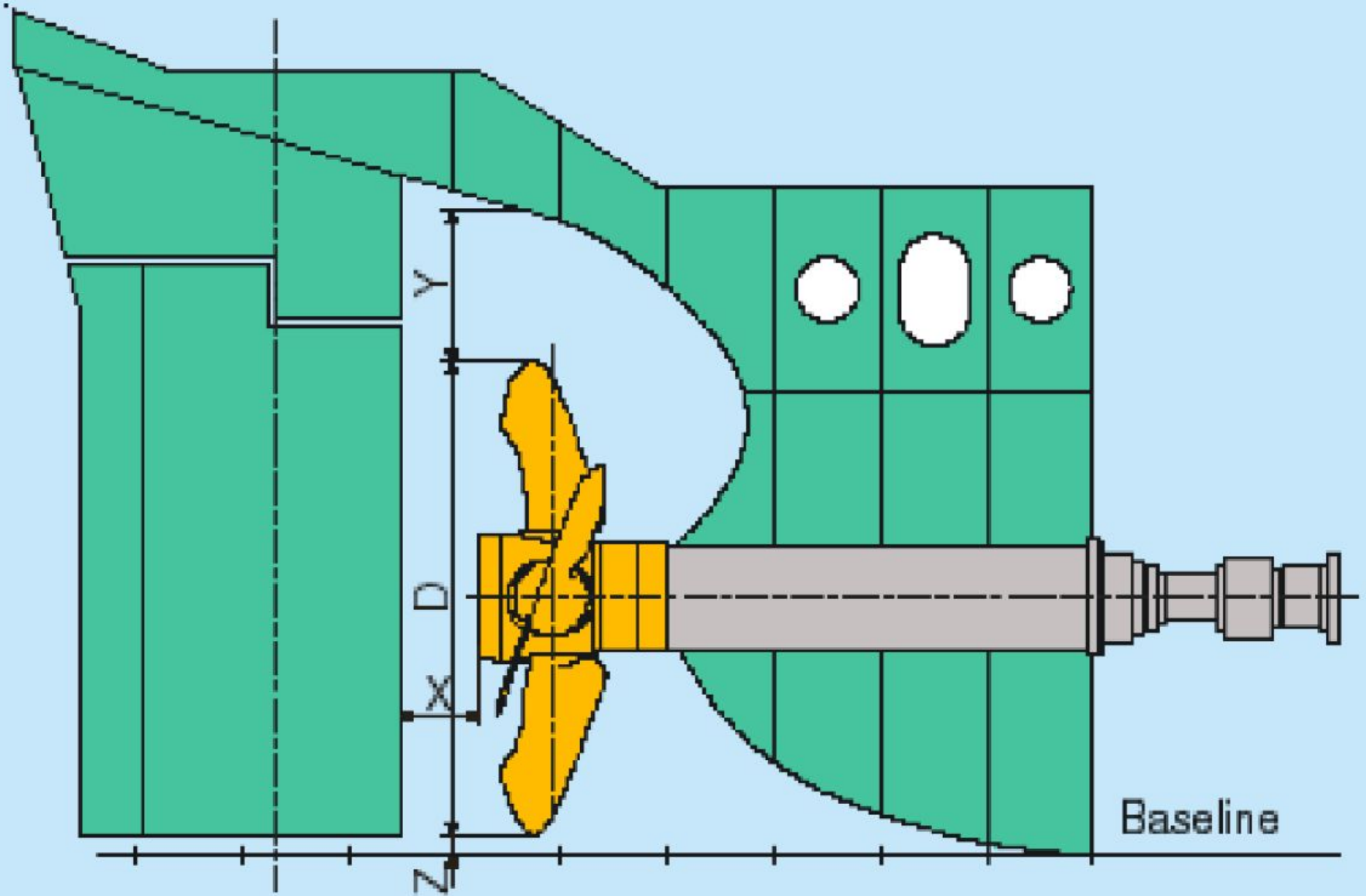
## Пропульсивная наделка на руле

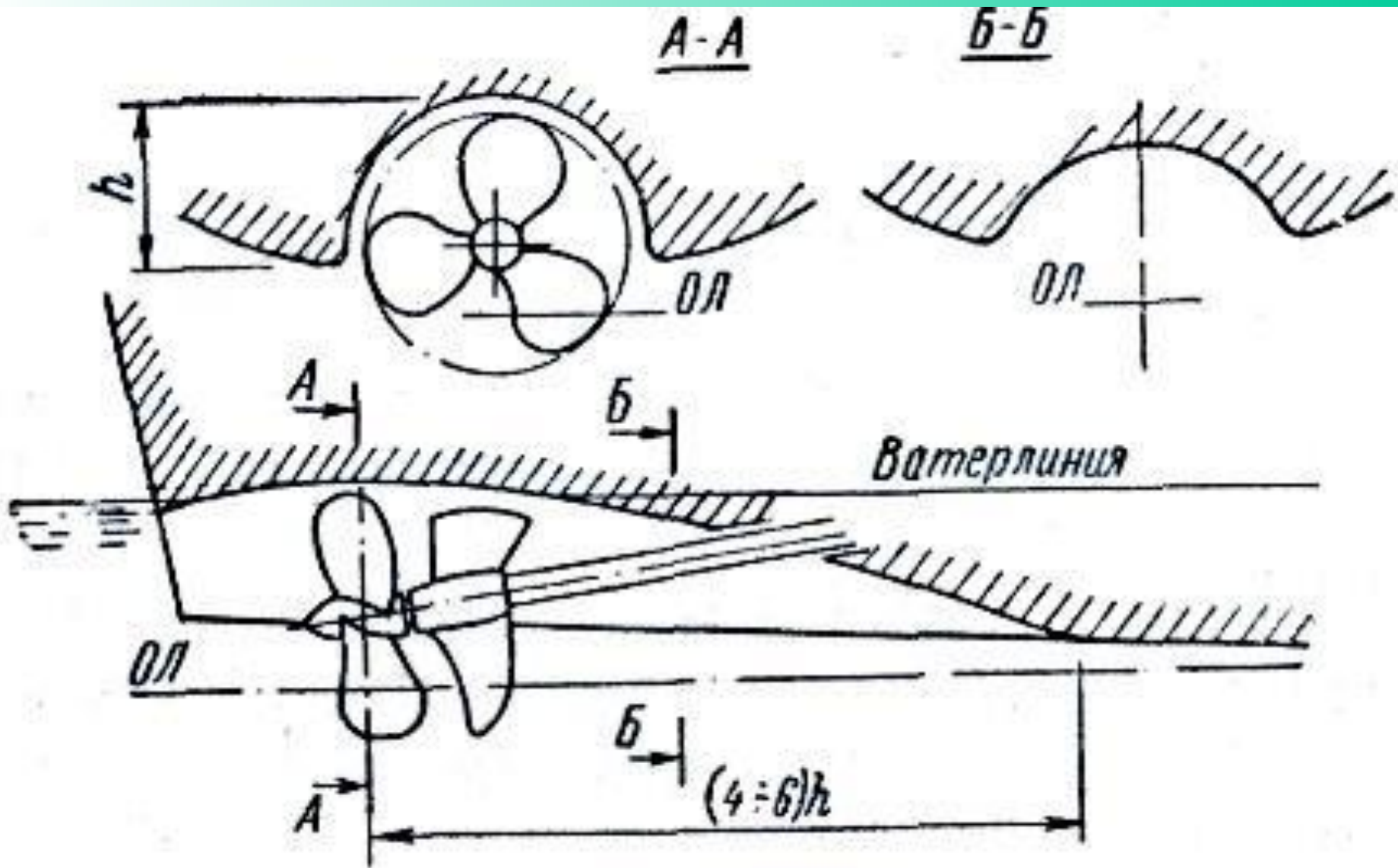


58  
56  
54  
52  
50  
48  
46  
44  
42  
40



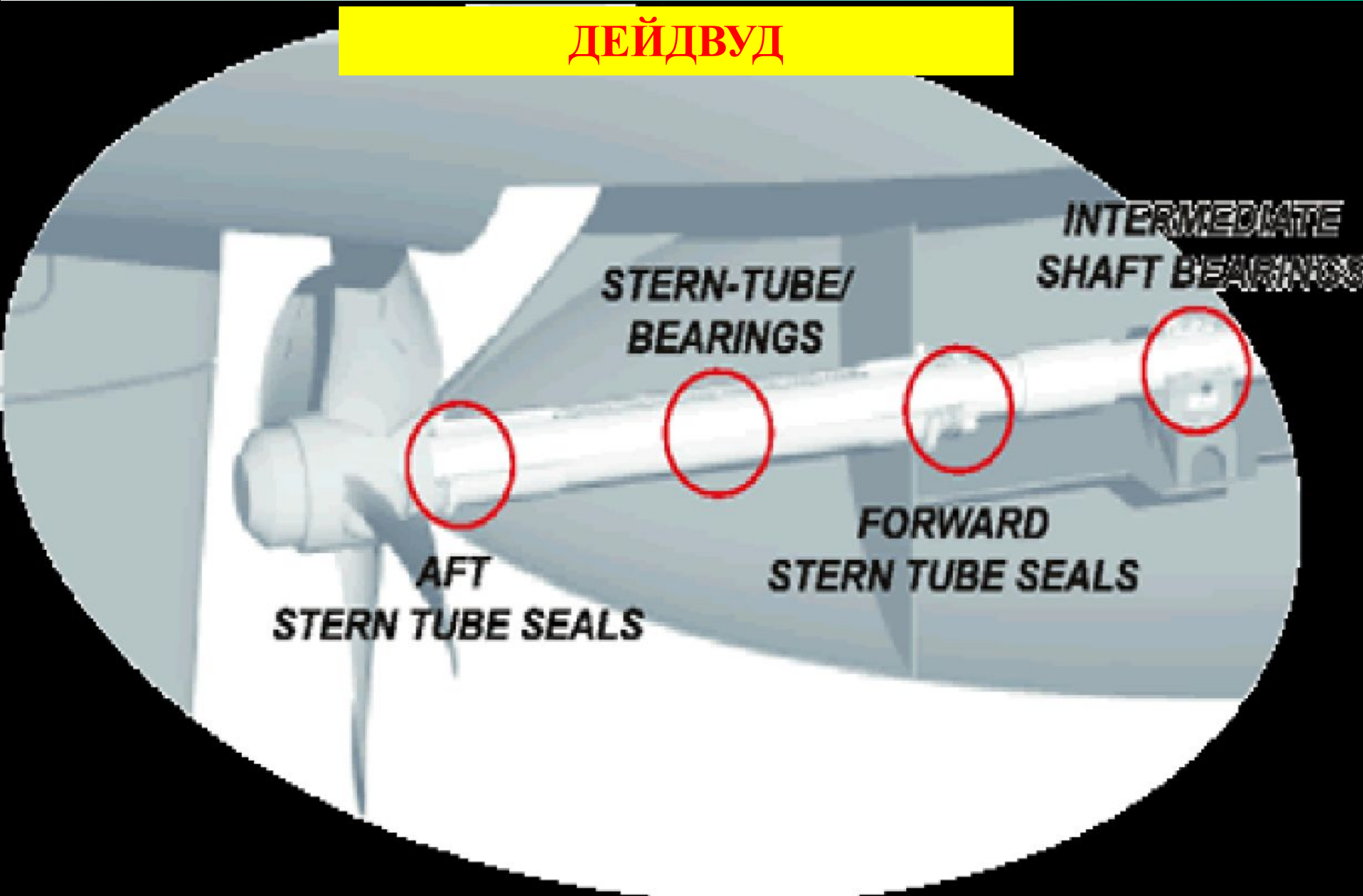




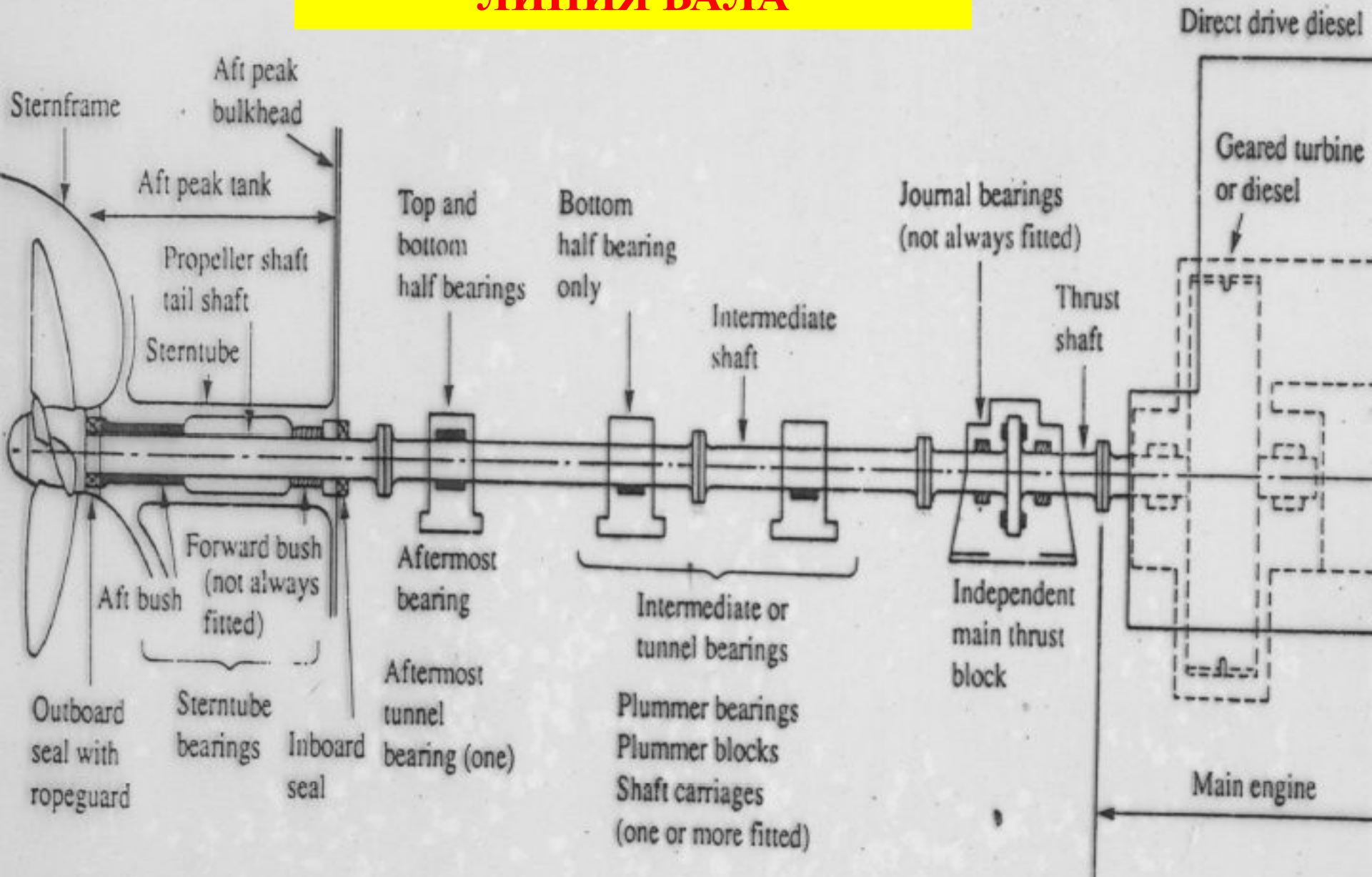


Гребной винт в туннеле.

# ДЕЙДВУД



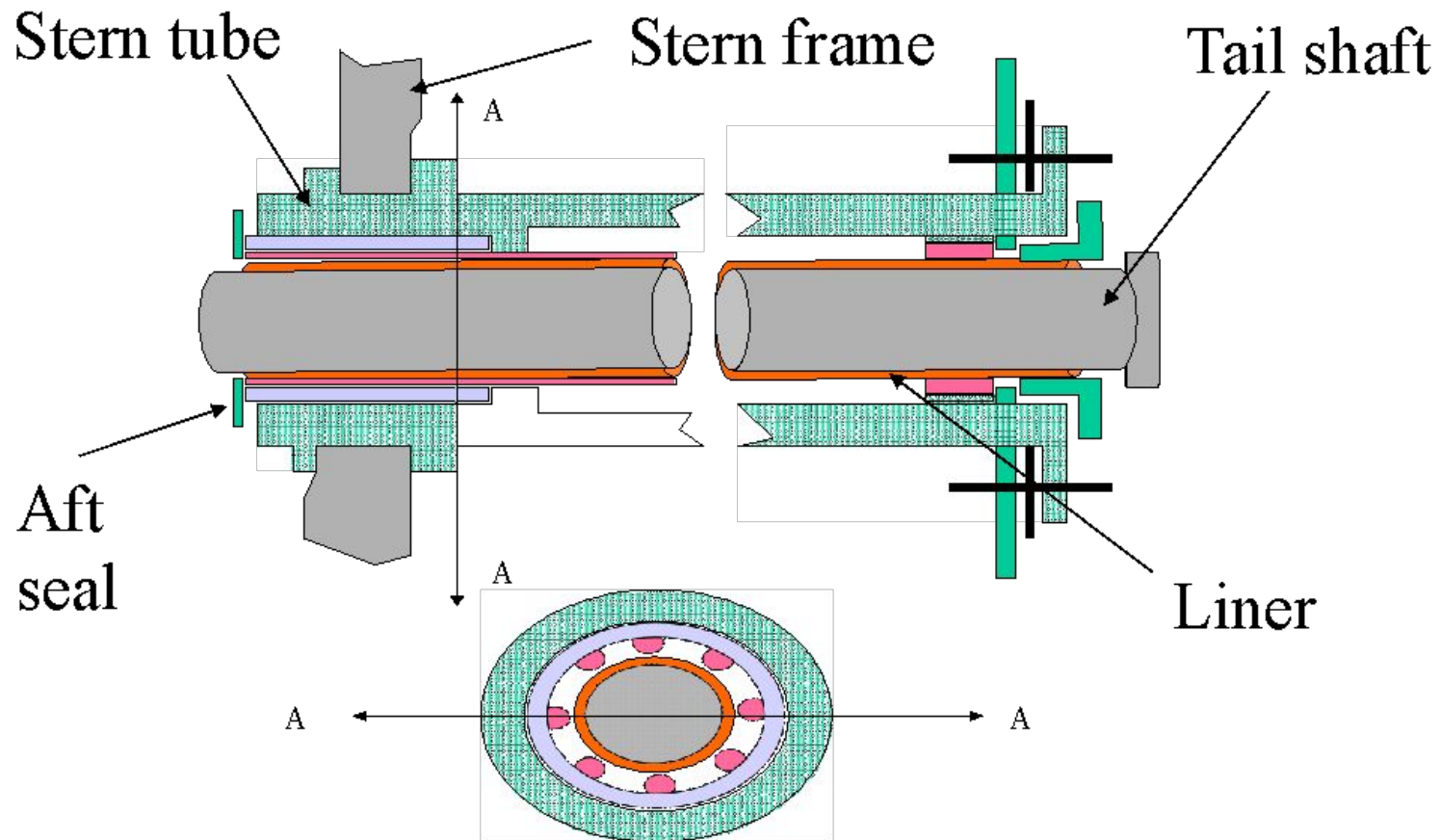
# ЛИНИЯ ВАЛА





# Water lubricated stern tube

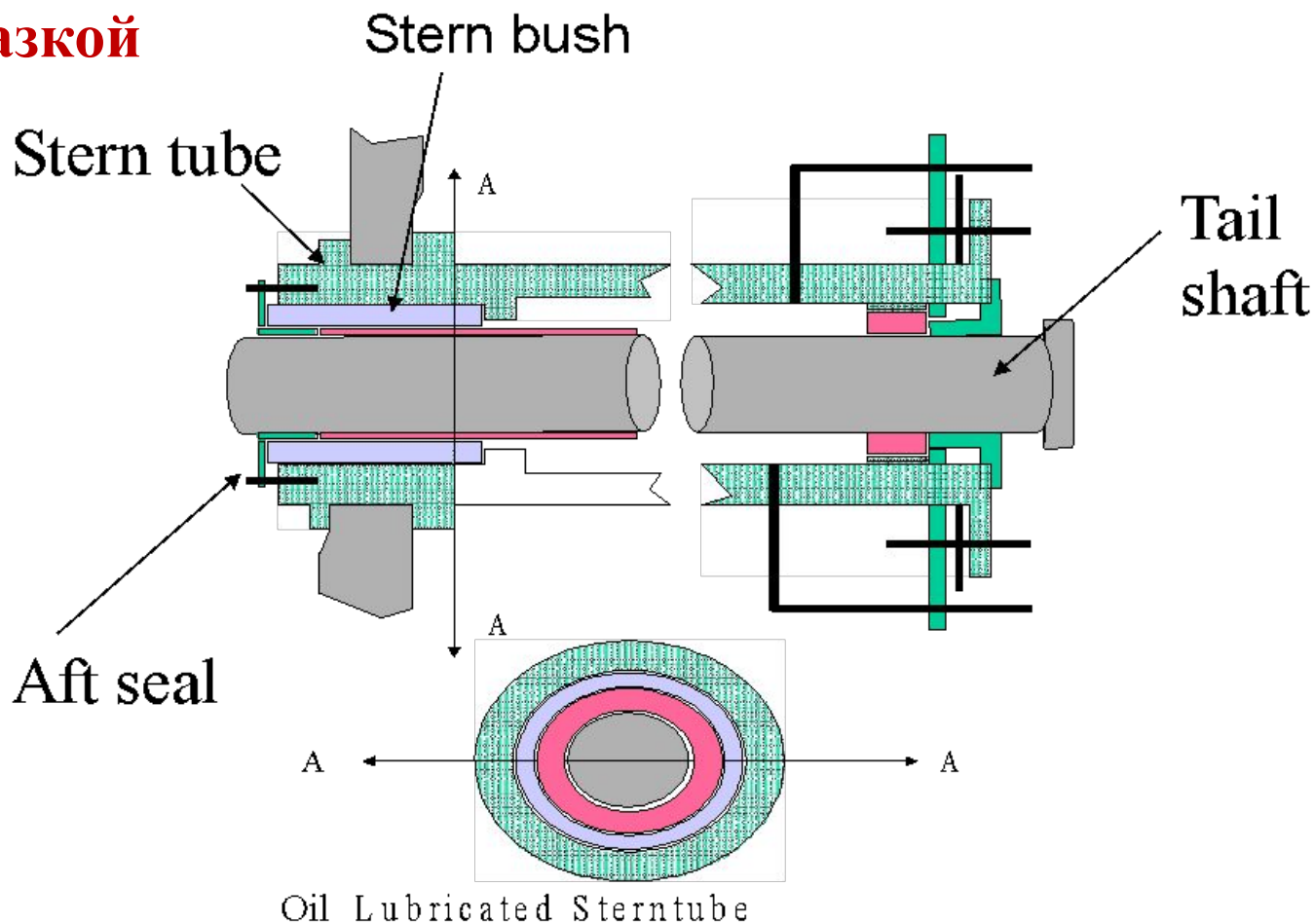
Дейдвудный подшипник с водяной смазкой



Water Cooled Sterntube

# Oil lubricated stern tube

Дейдвудный подшипник с масляной смазкой



Oil Lubricated Sterntube



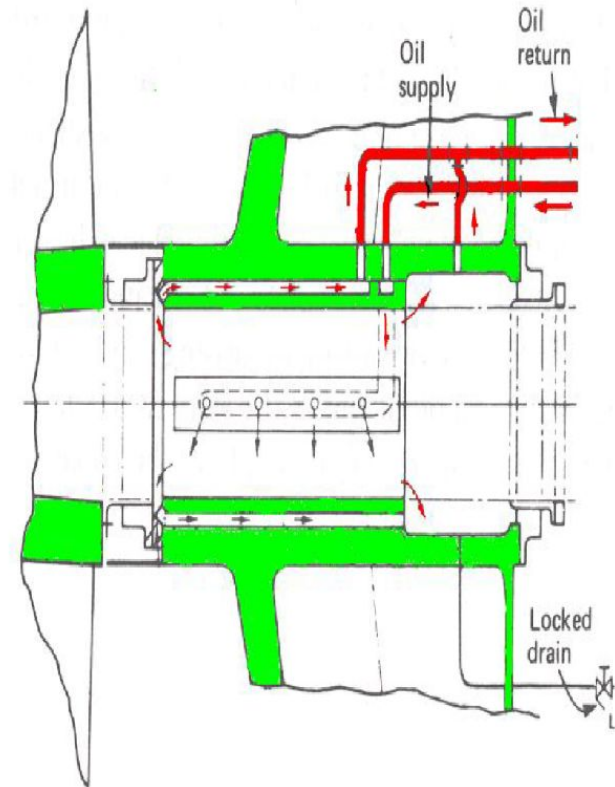
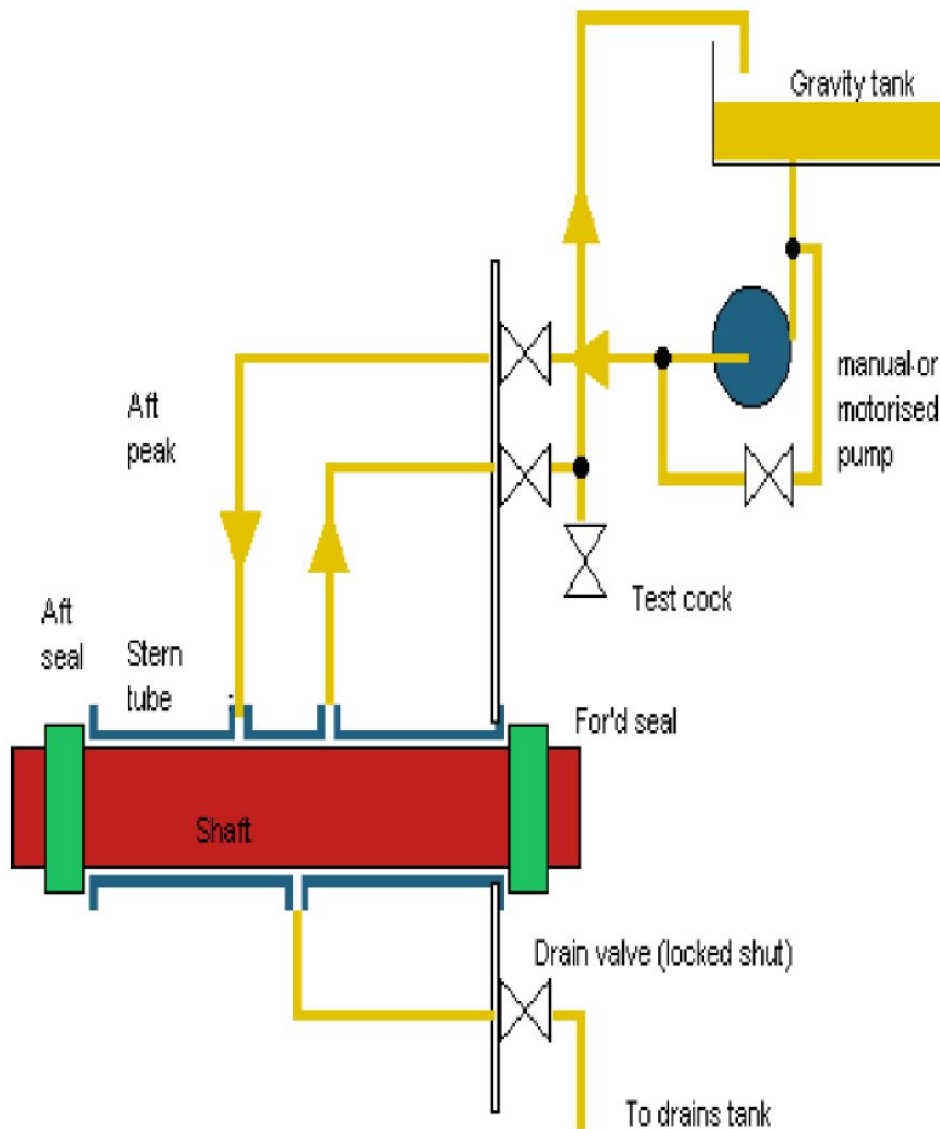
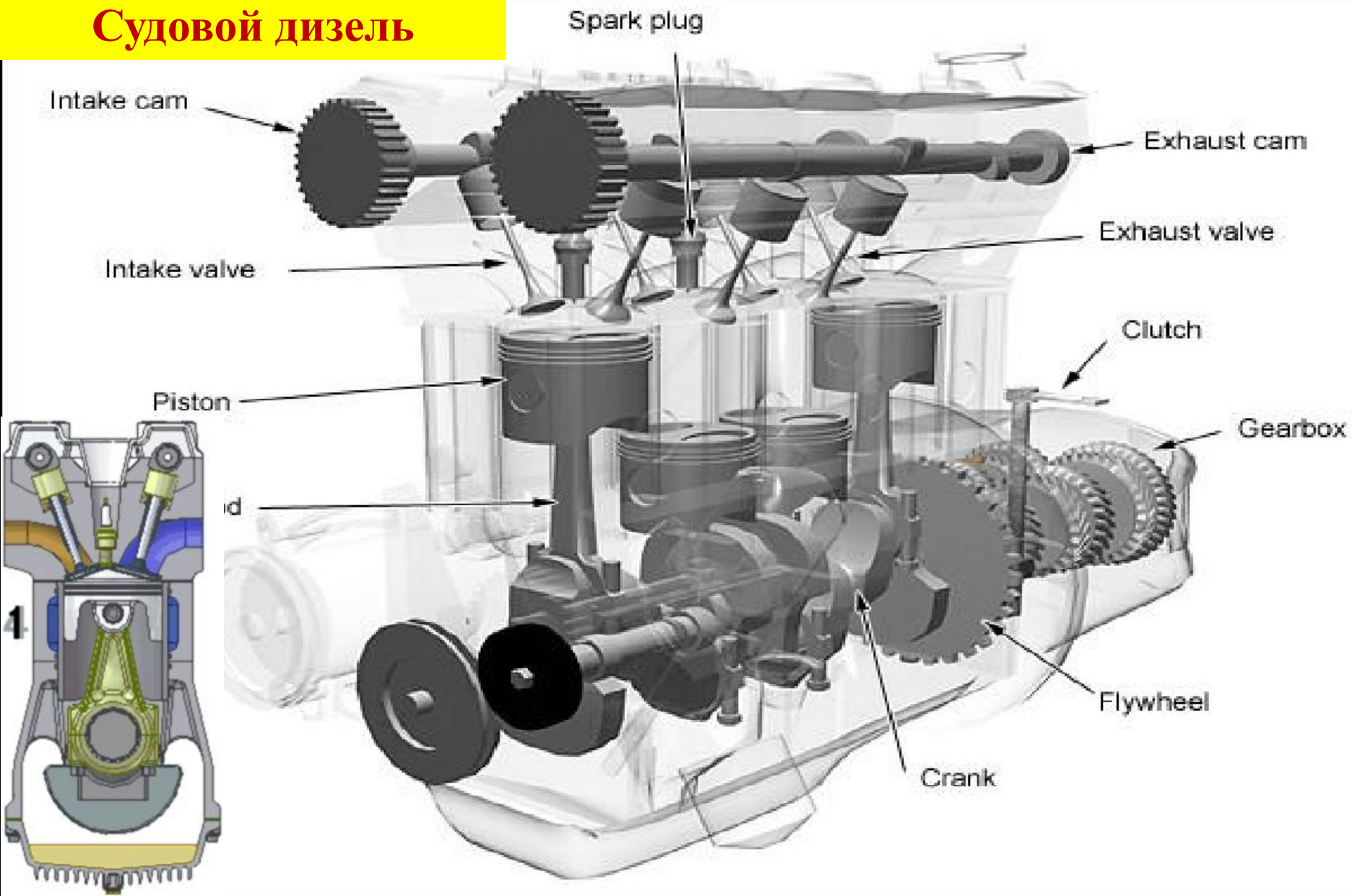


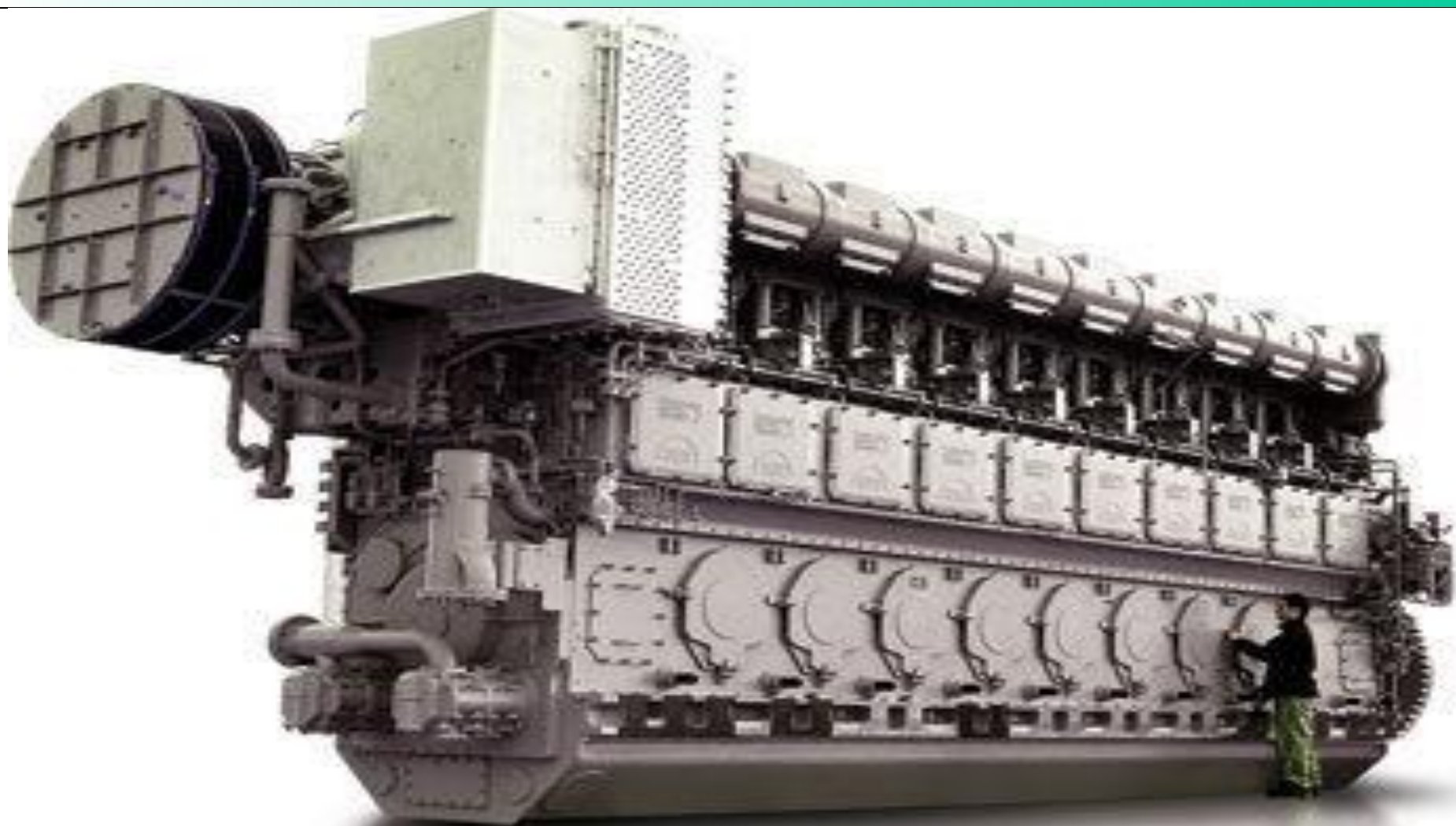
Figure 11.4 Oil lubricated stern tube bearing



# Судовой дизель

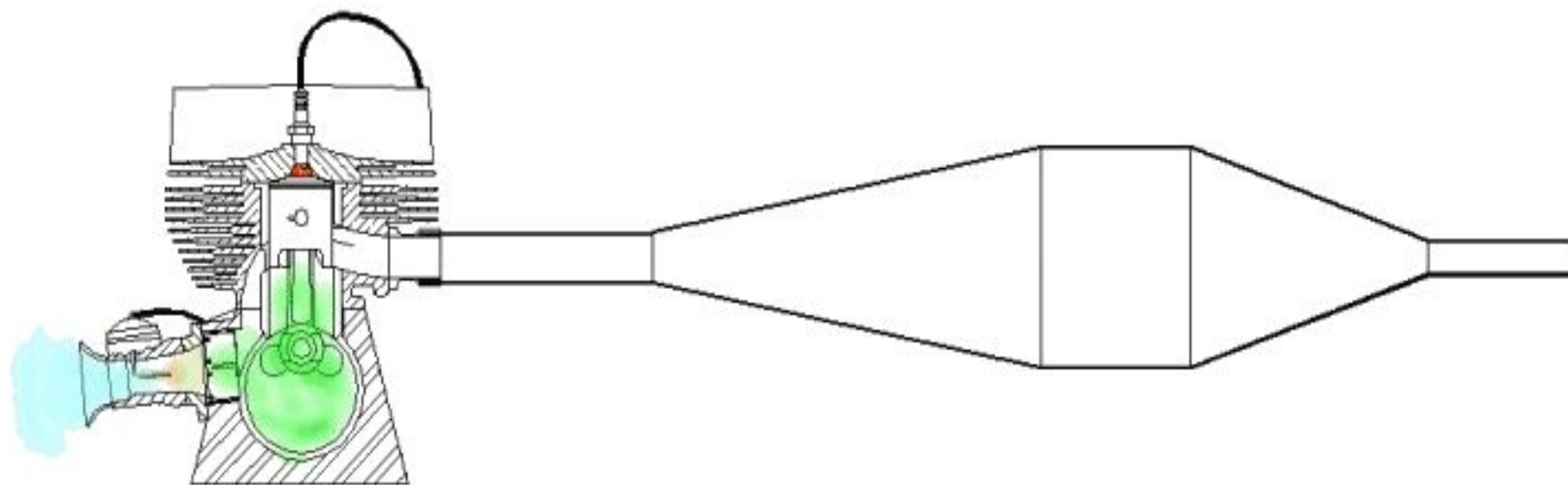
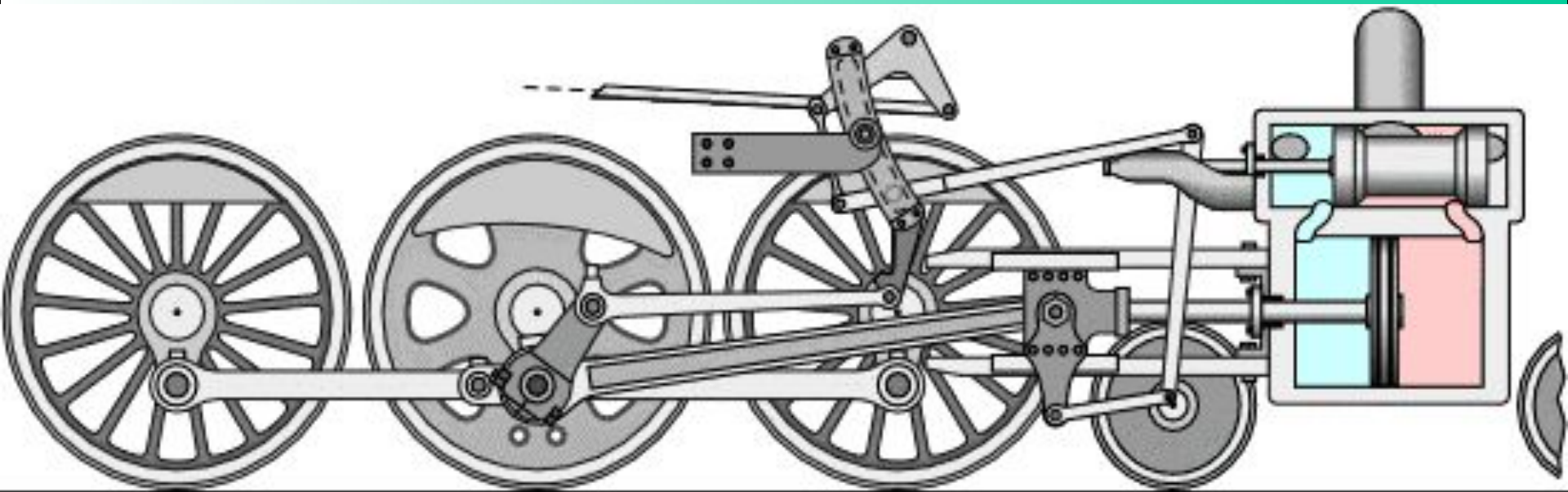


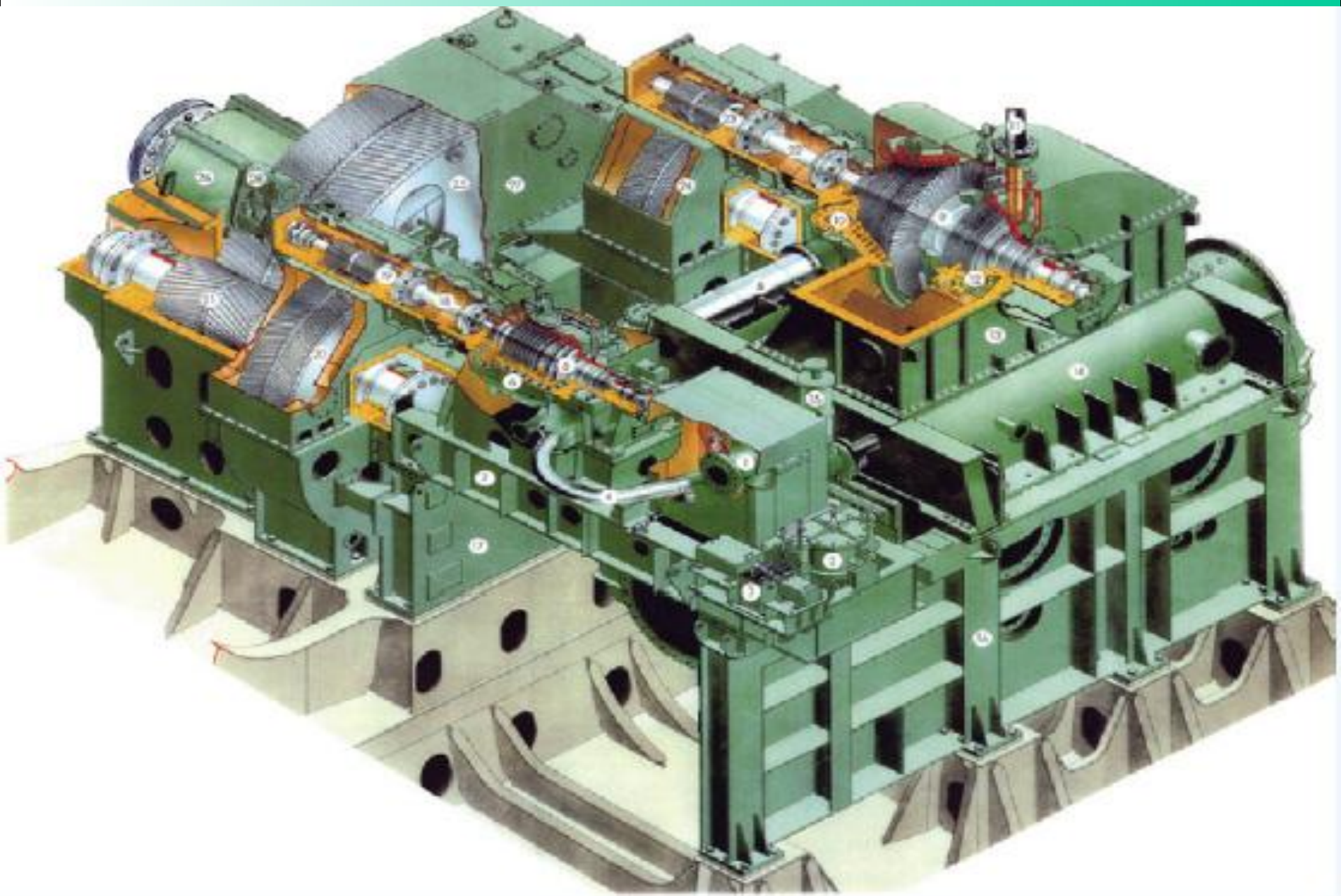




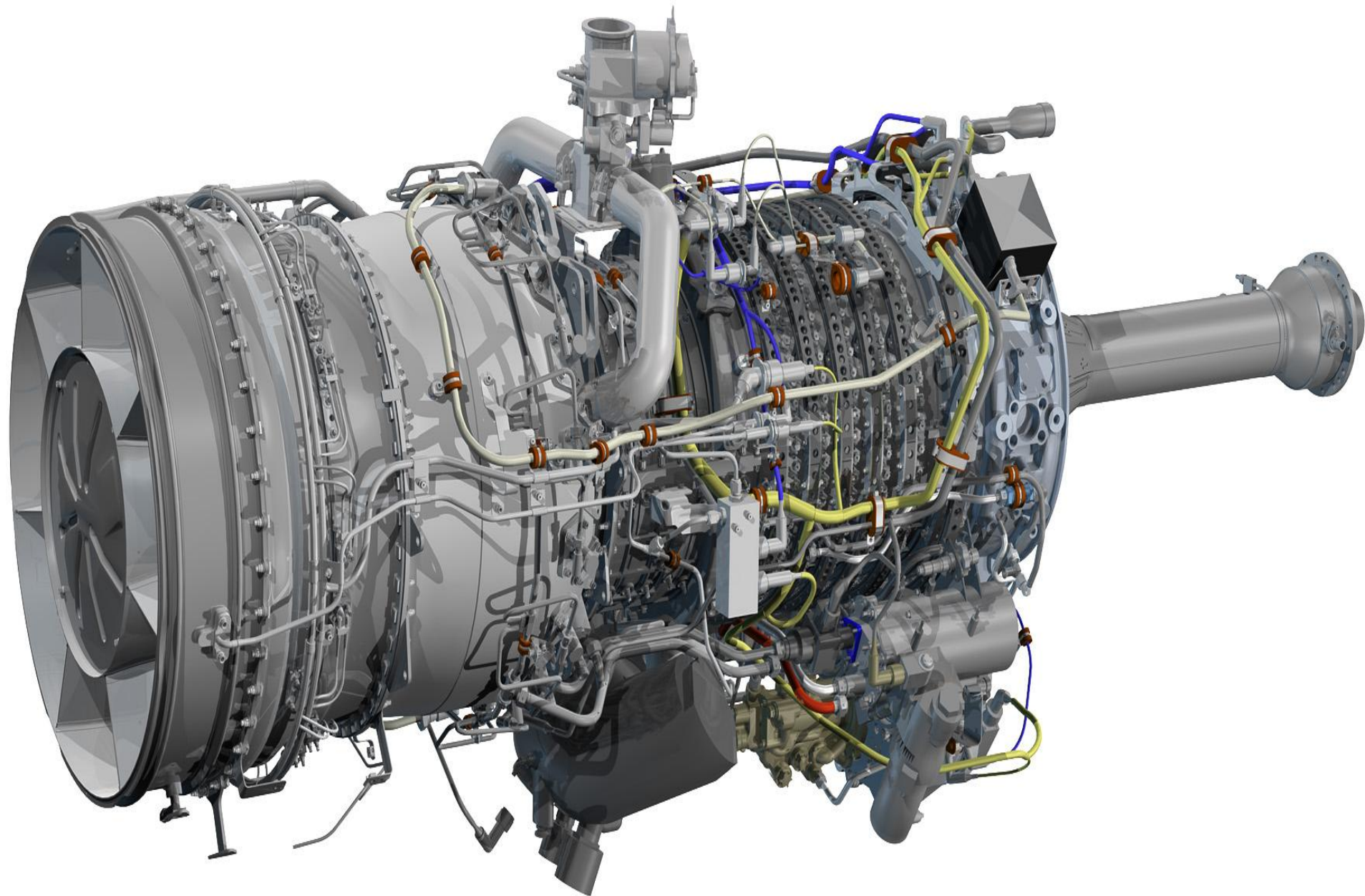
















# PROPELLER GEOMETRY

## ГЕОМЕТРИЯ ГРЕБНОГО ВИНТА

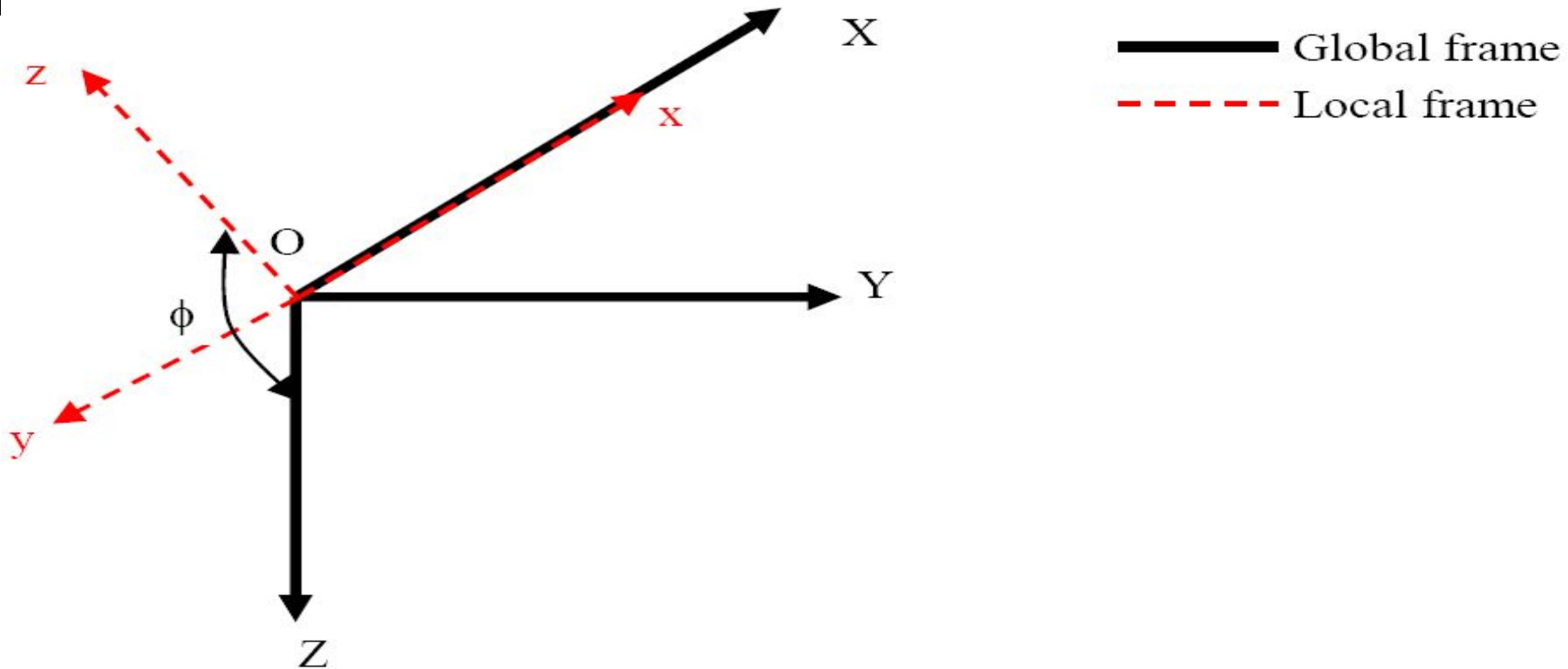
# Dictionary of Ship Hydrodynamics

- 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.



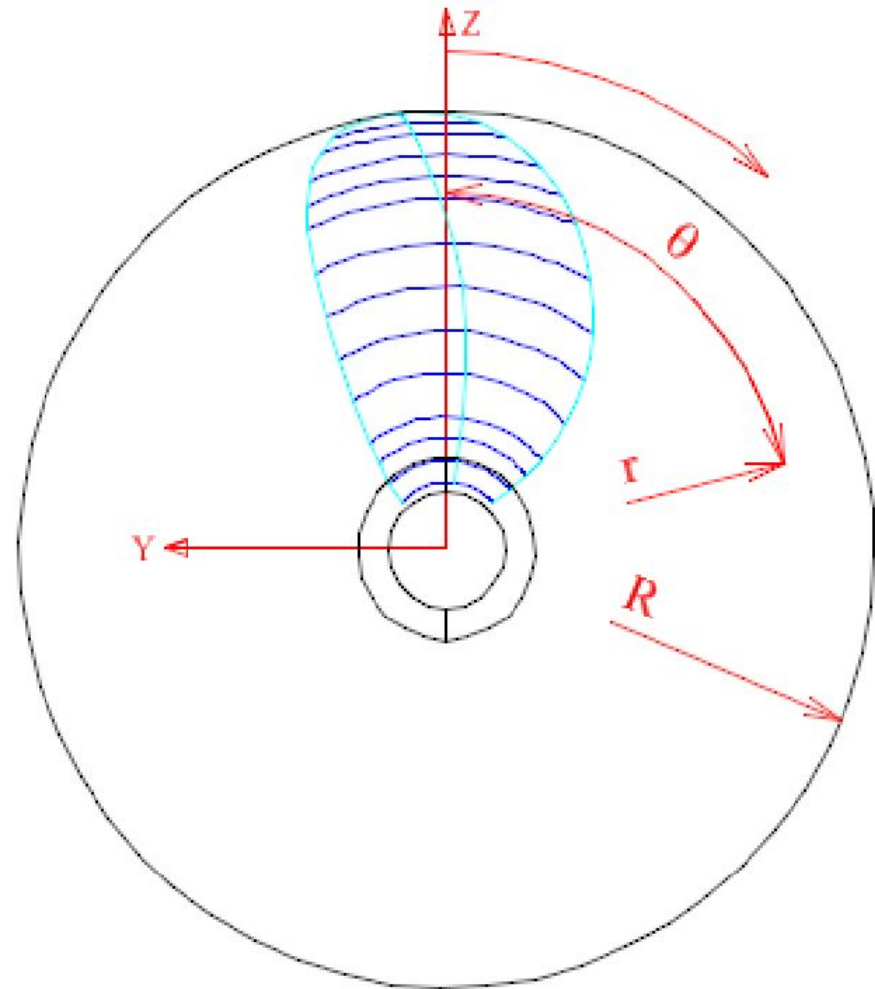
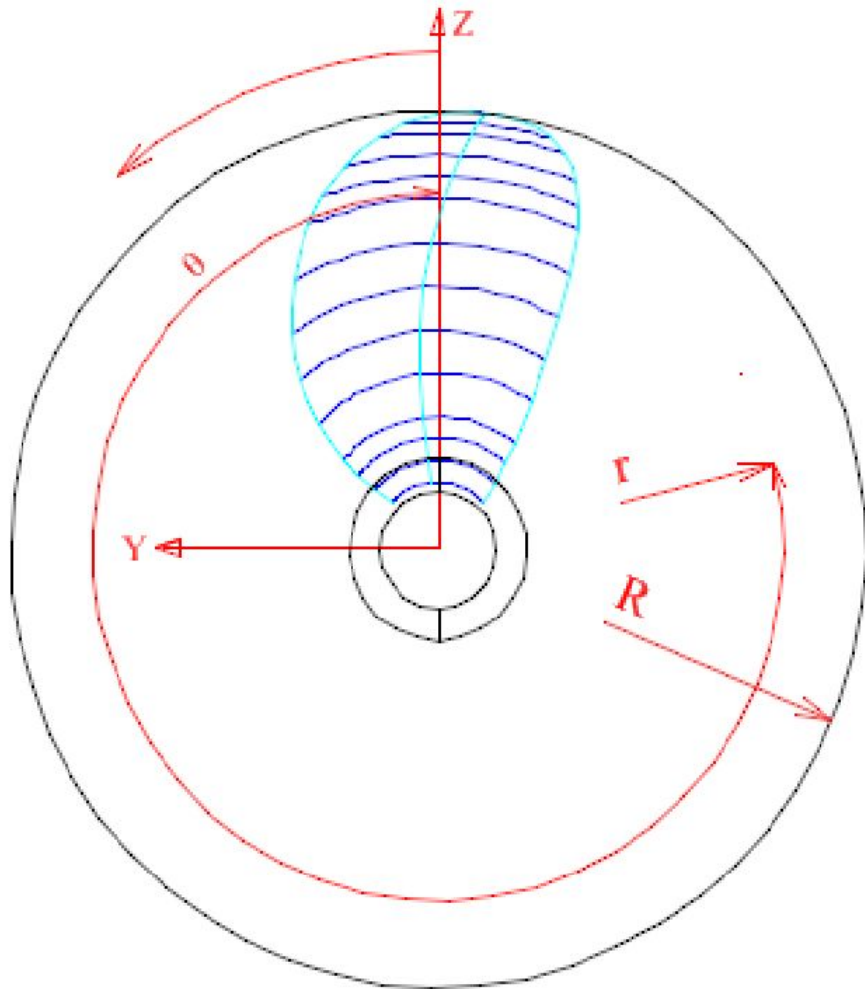
# Dictionary of Ship Hydrodynamics

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

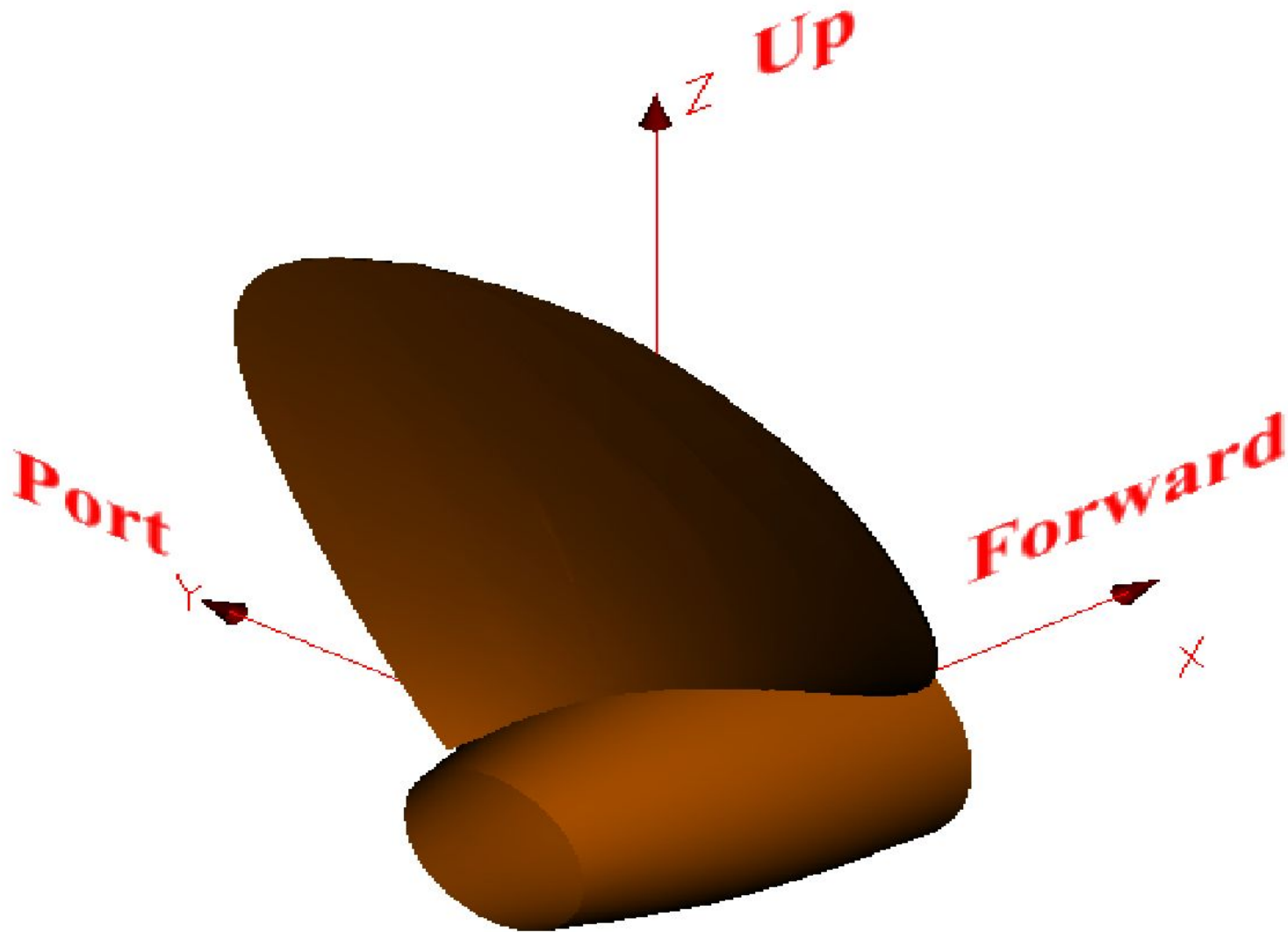




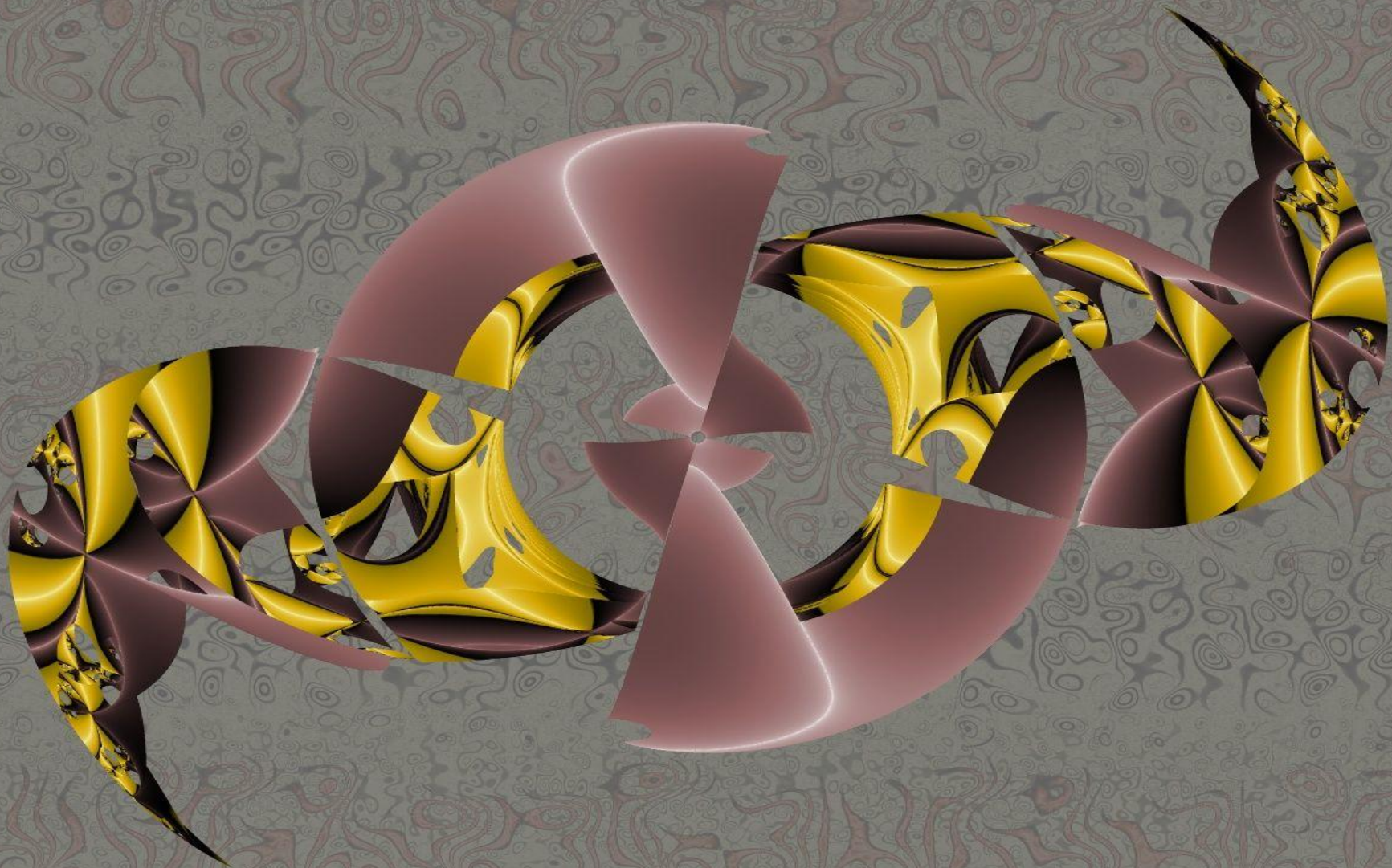
# Основная цилиндрическая система координат - (вид сзади)



# Декартова система координат

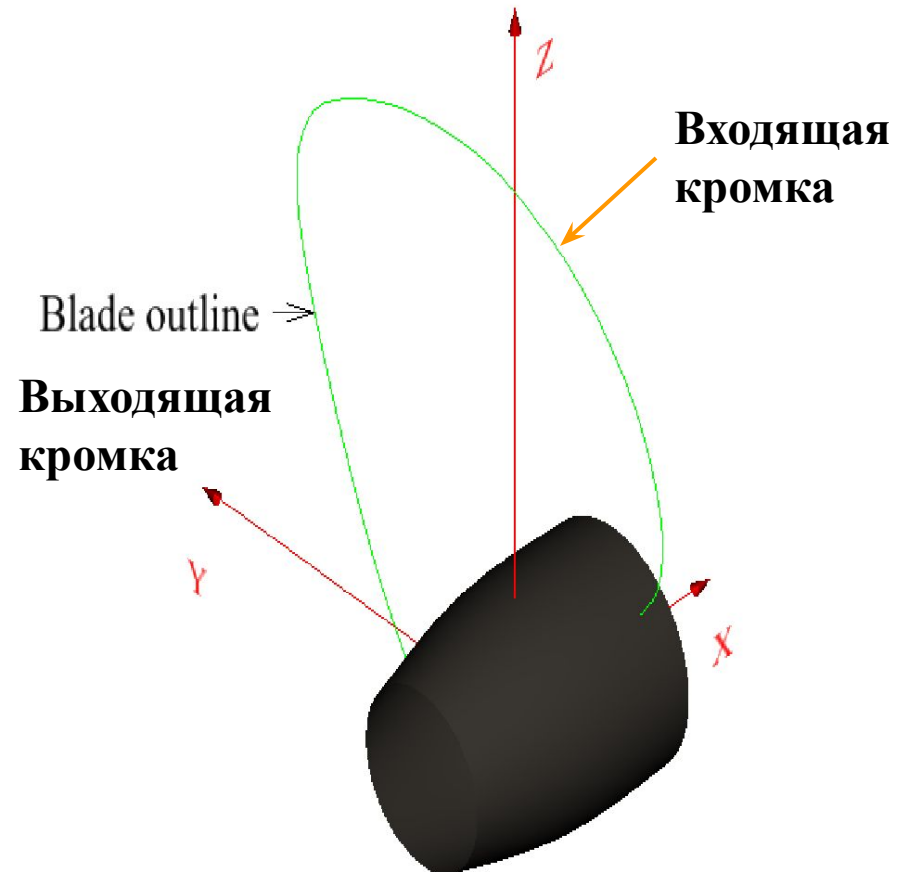
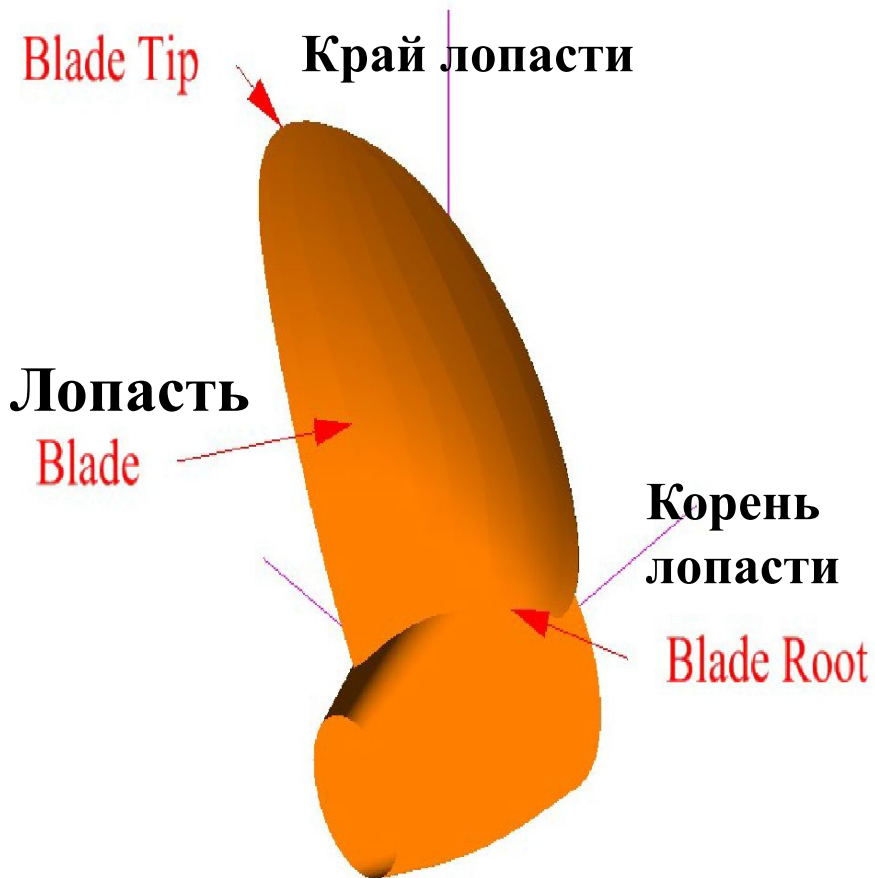


## Описание гребных винтов

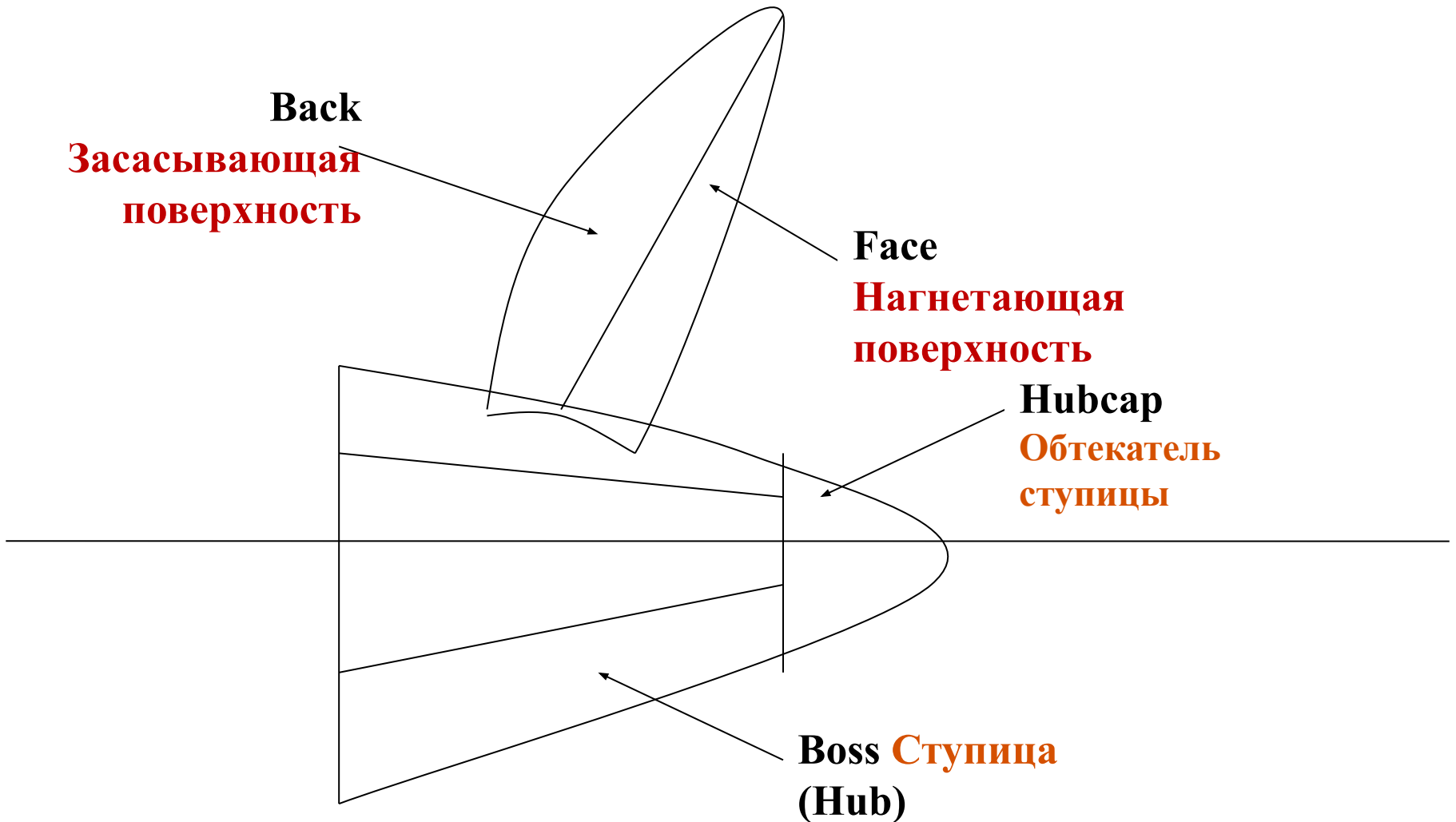




# Основные понятия и определения



# Гребной винт: геометрия и терминология



## Propeller Materials\ МАТЕРИАЛ ГВ

Manganese bronze

Nickel manganese bronze

Nickel aluminum bronze

CF-4 Stainless steel

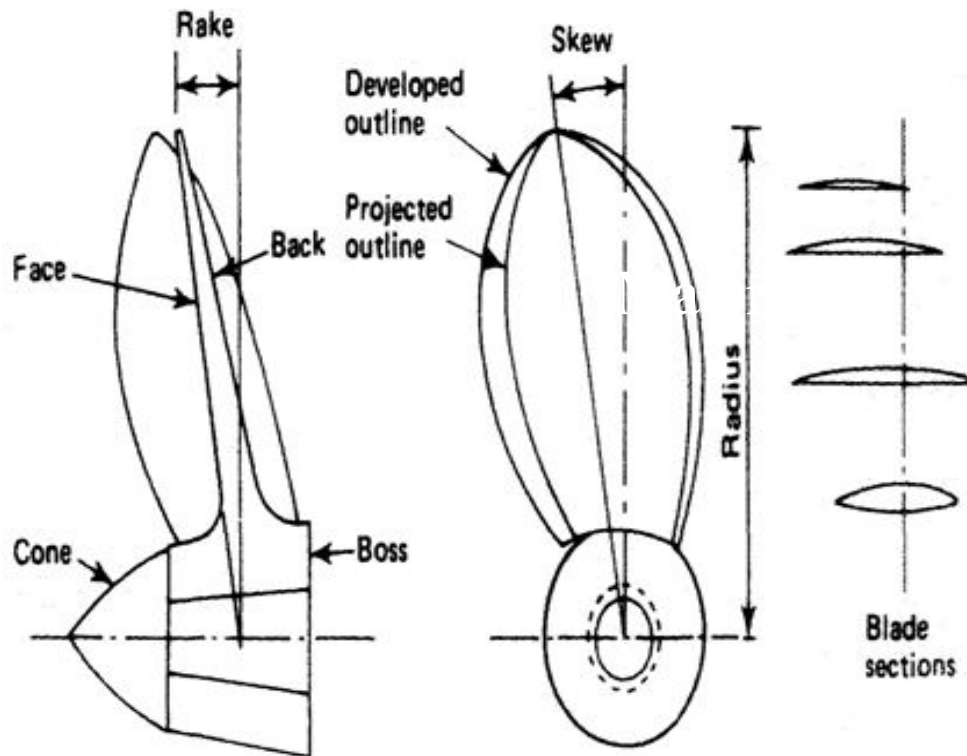
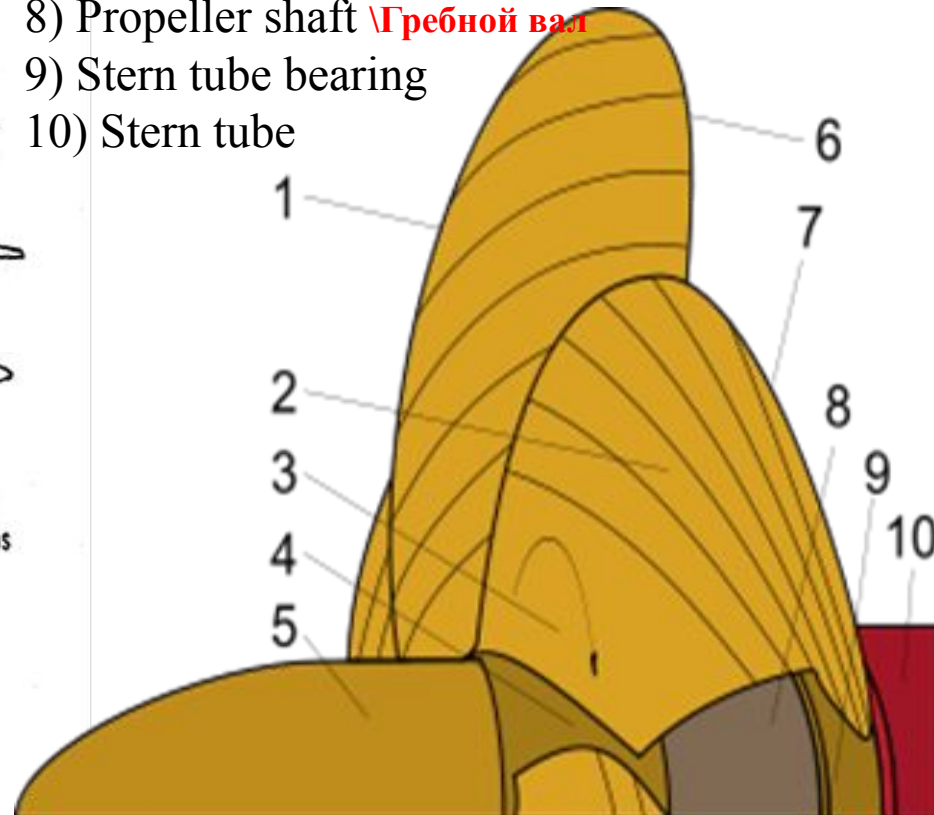


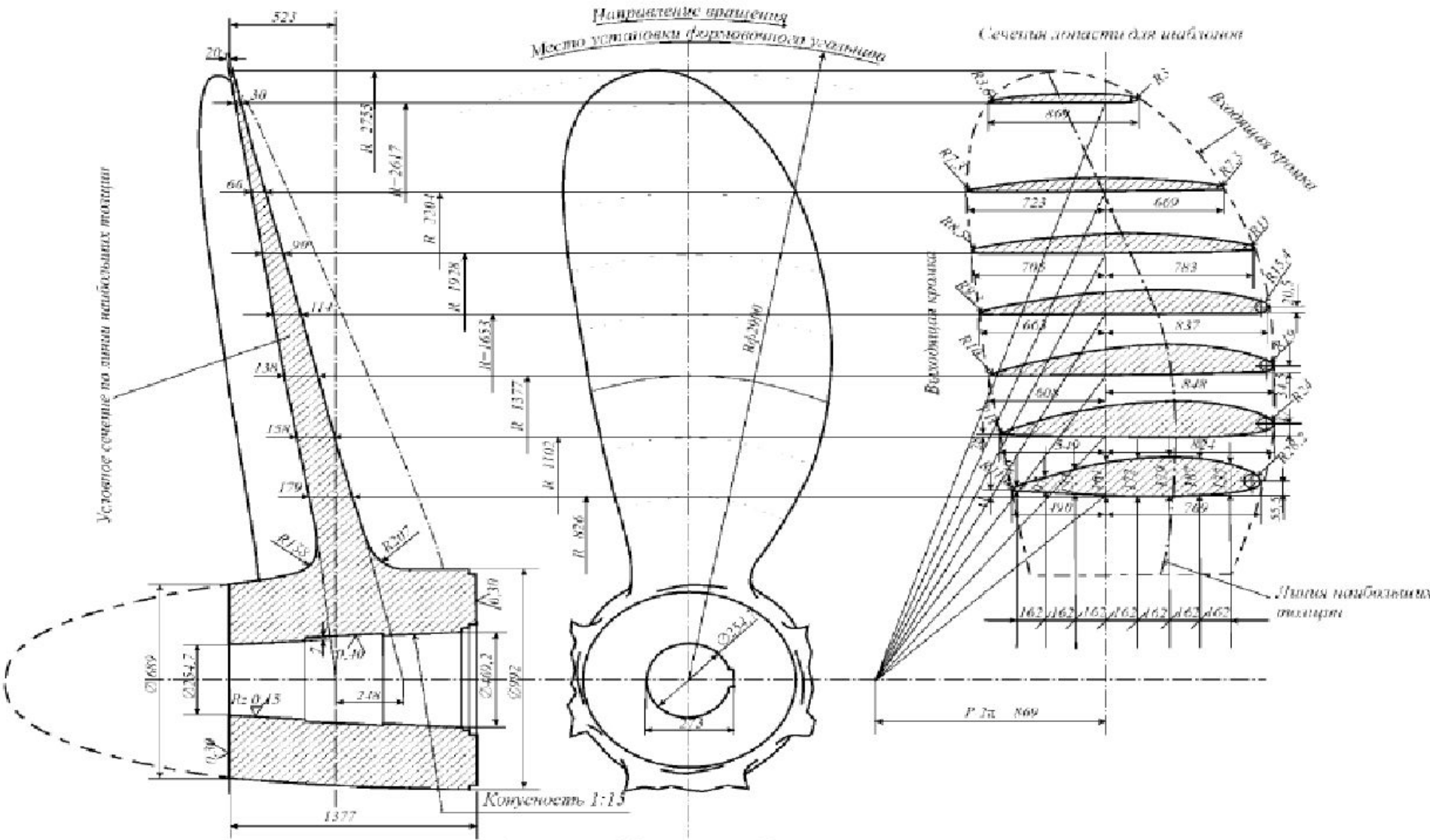
Figure 11.5 Solid propeller

- 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



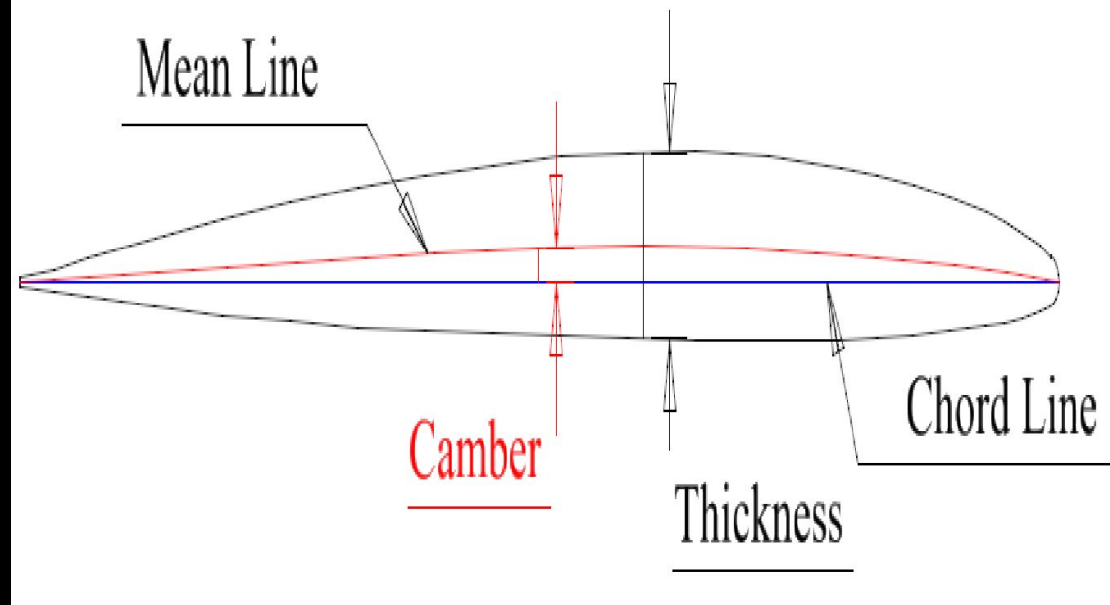
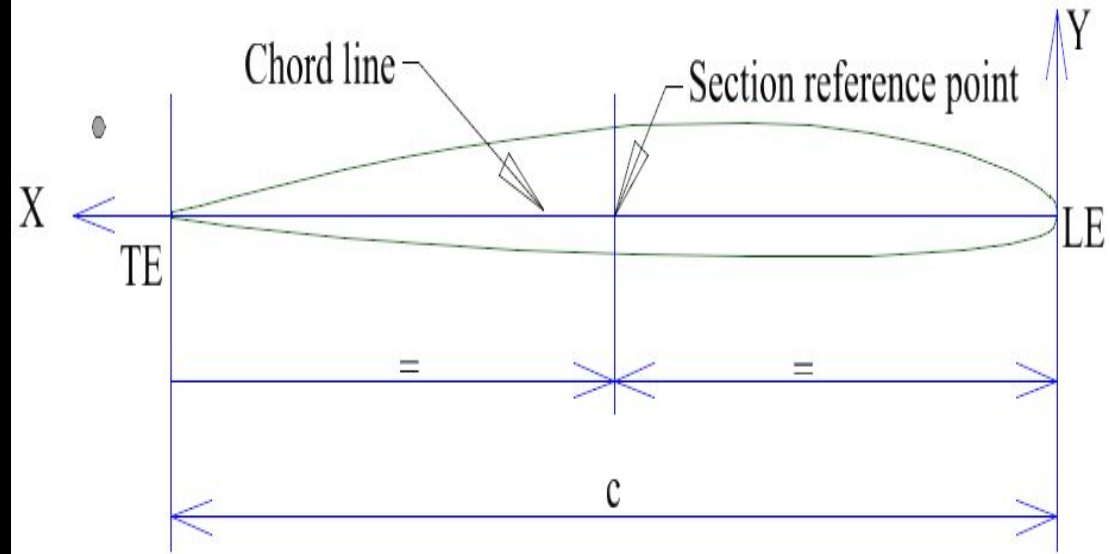
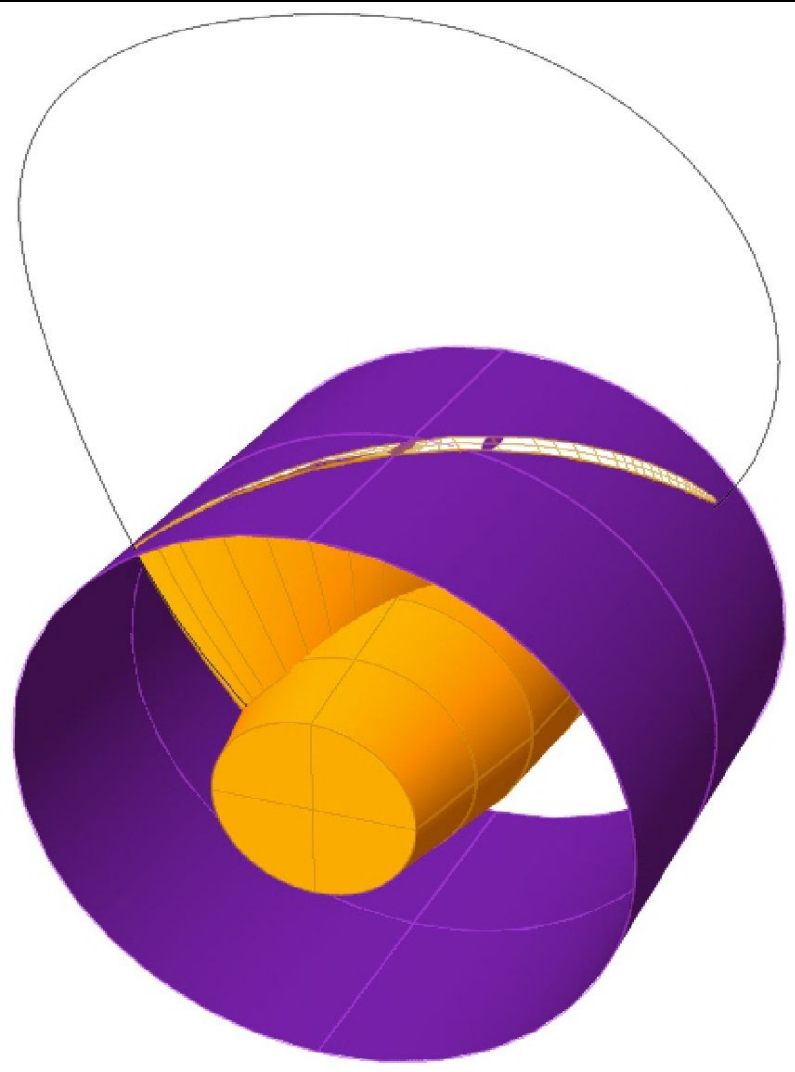




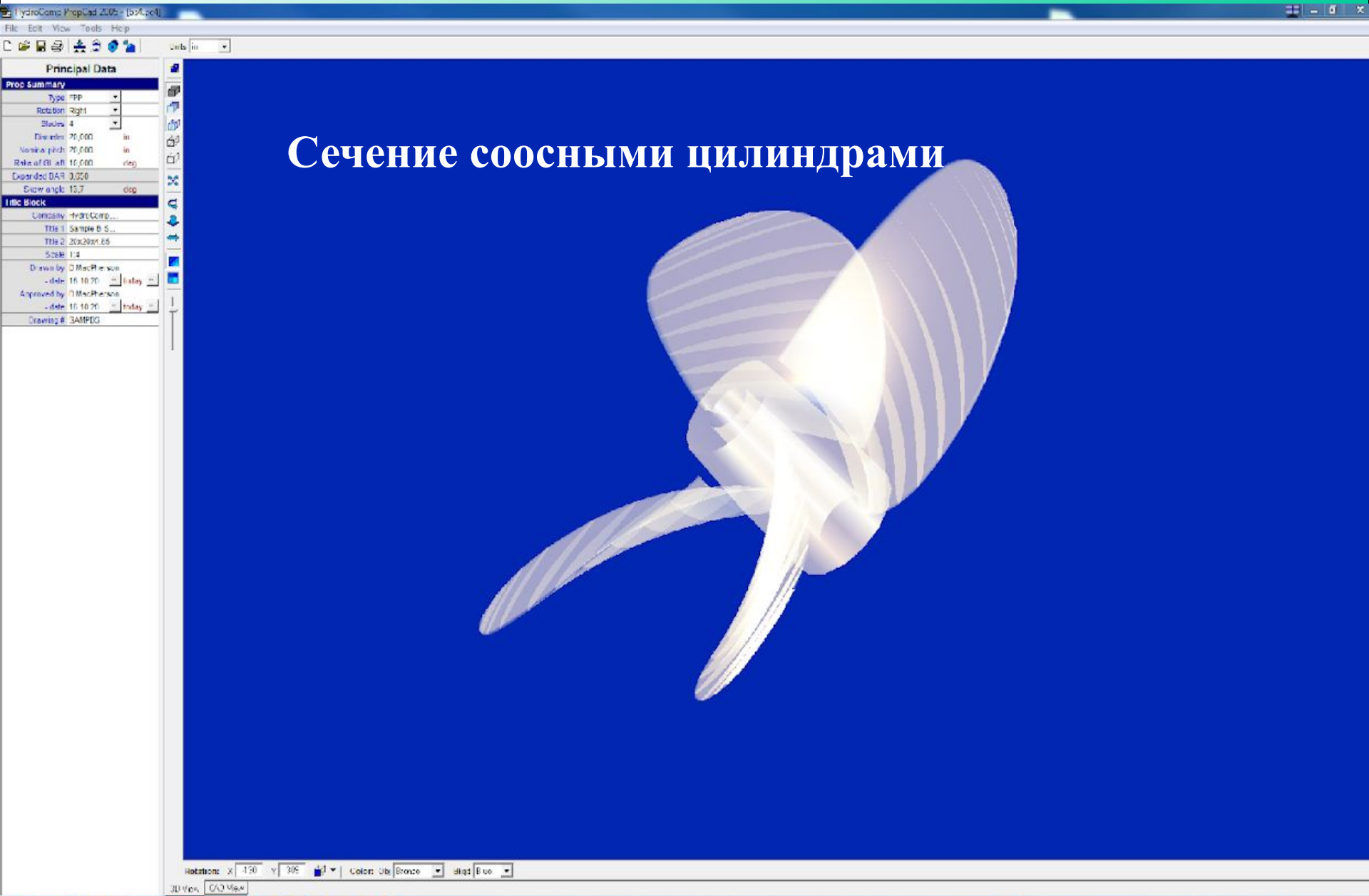


Чертеж гребного винта

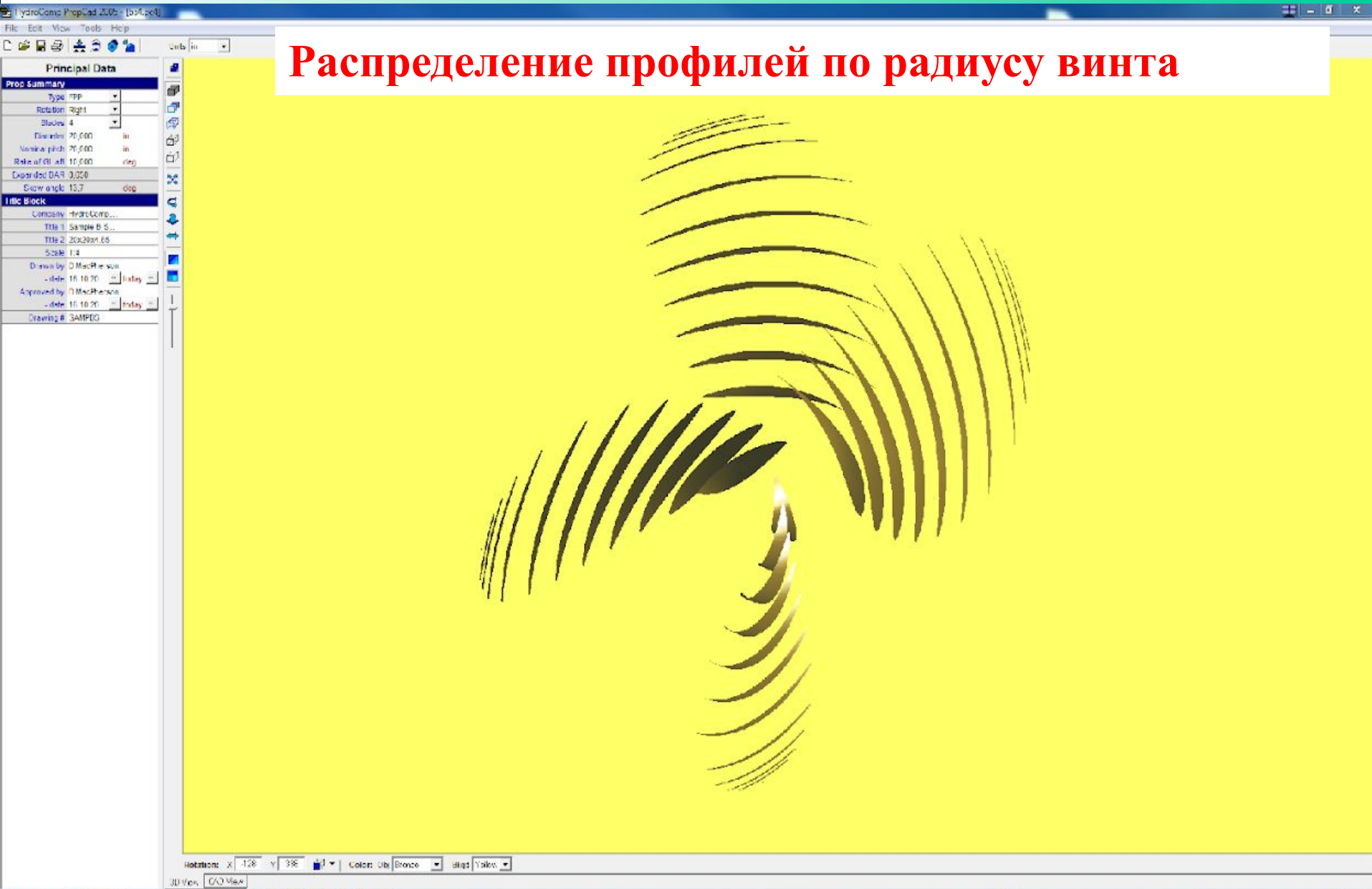
# Сечение соосным цилиндром

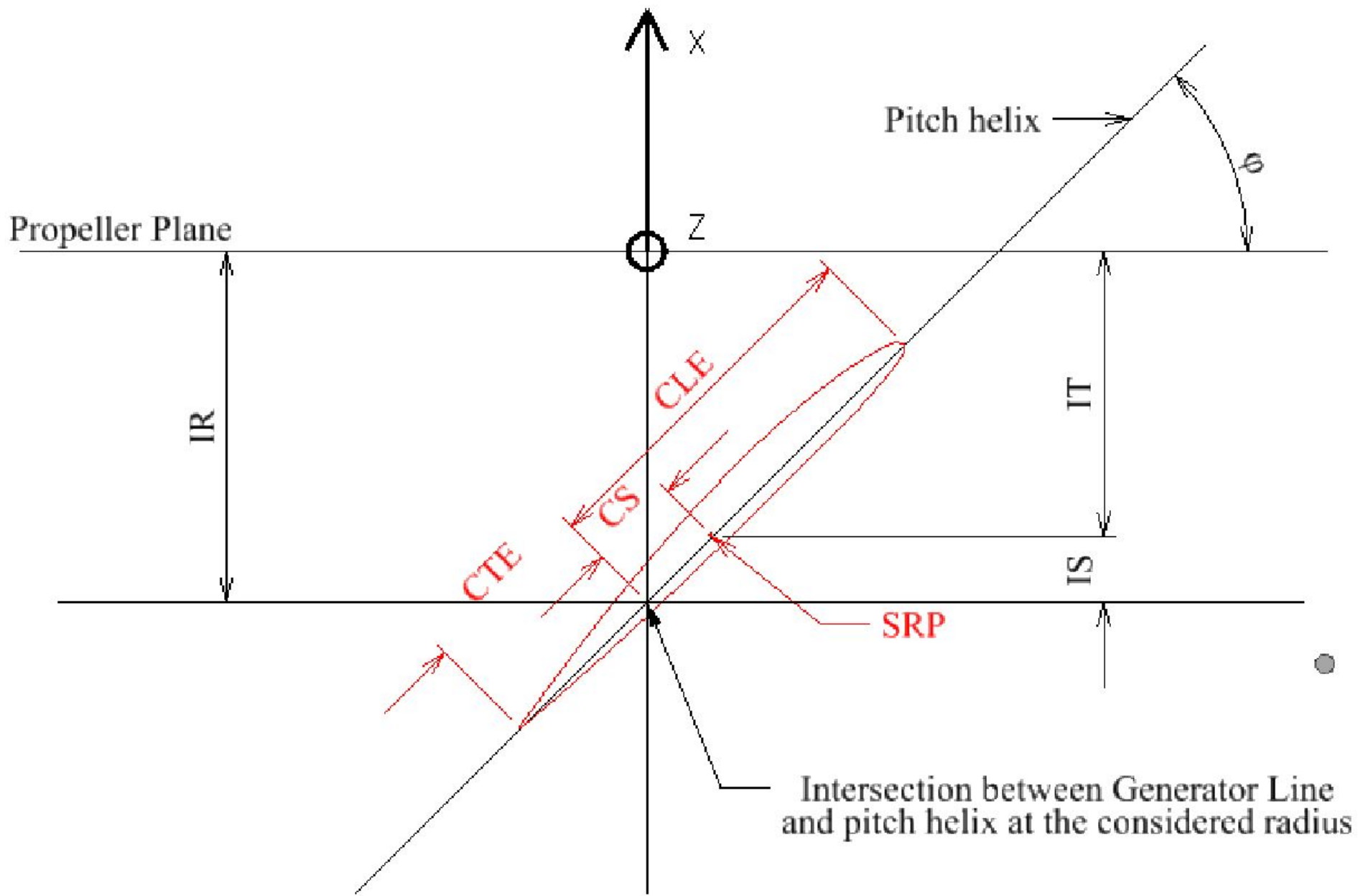




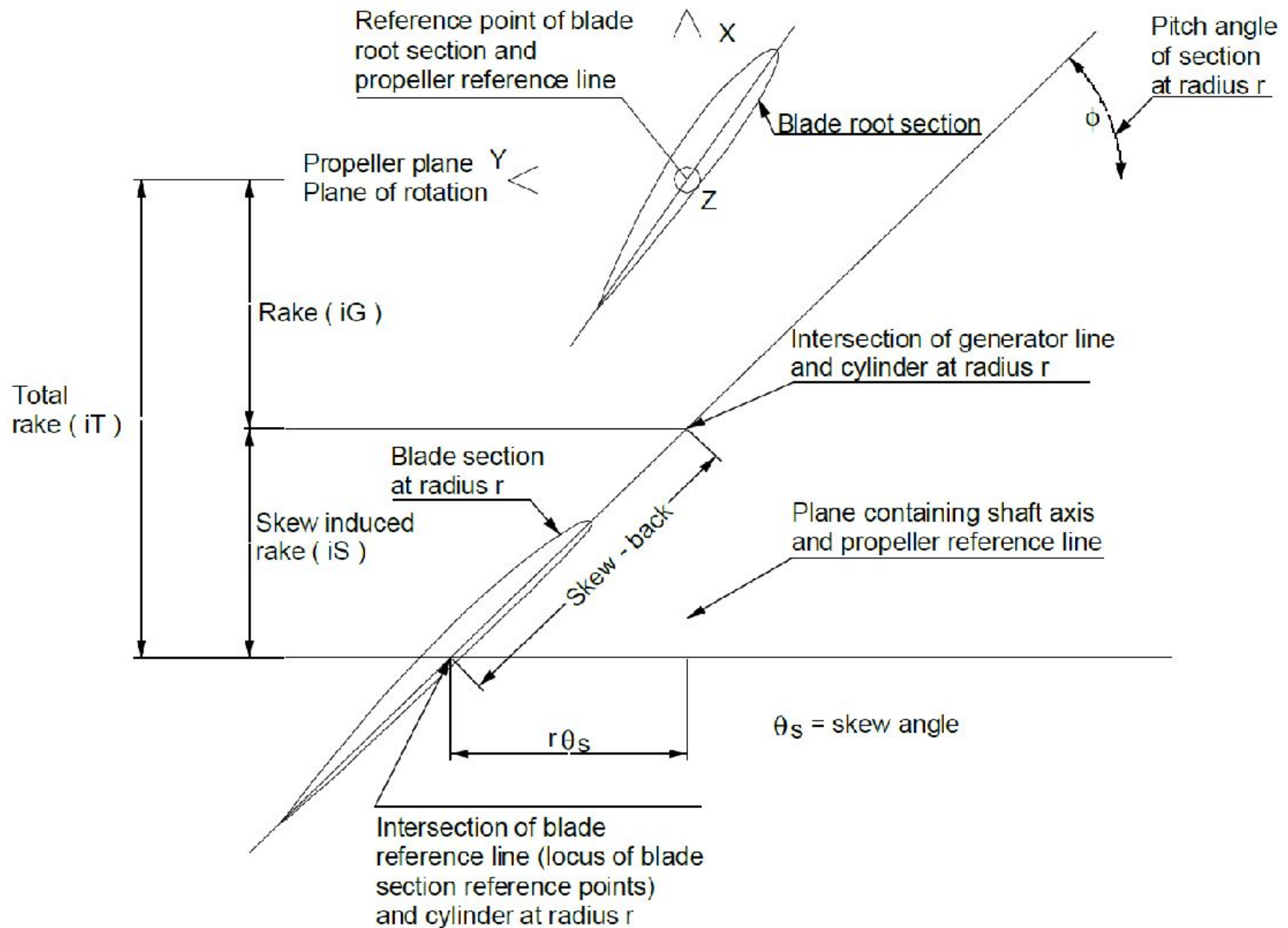


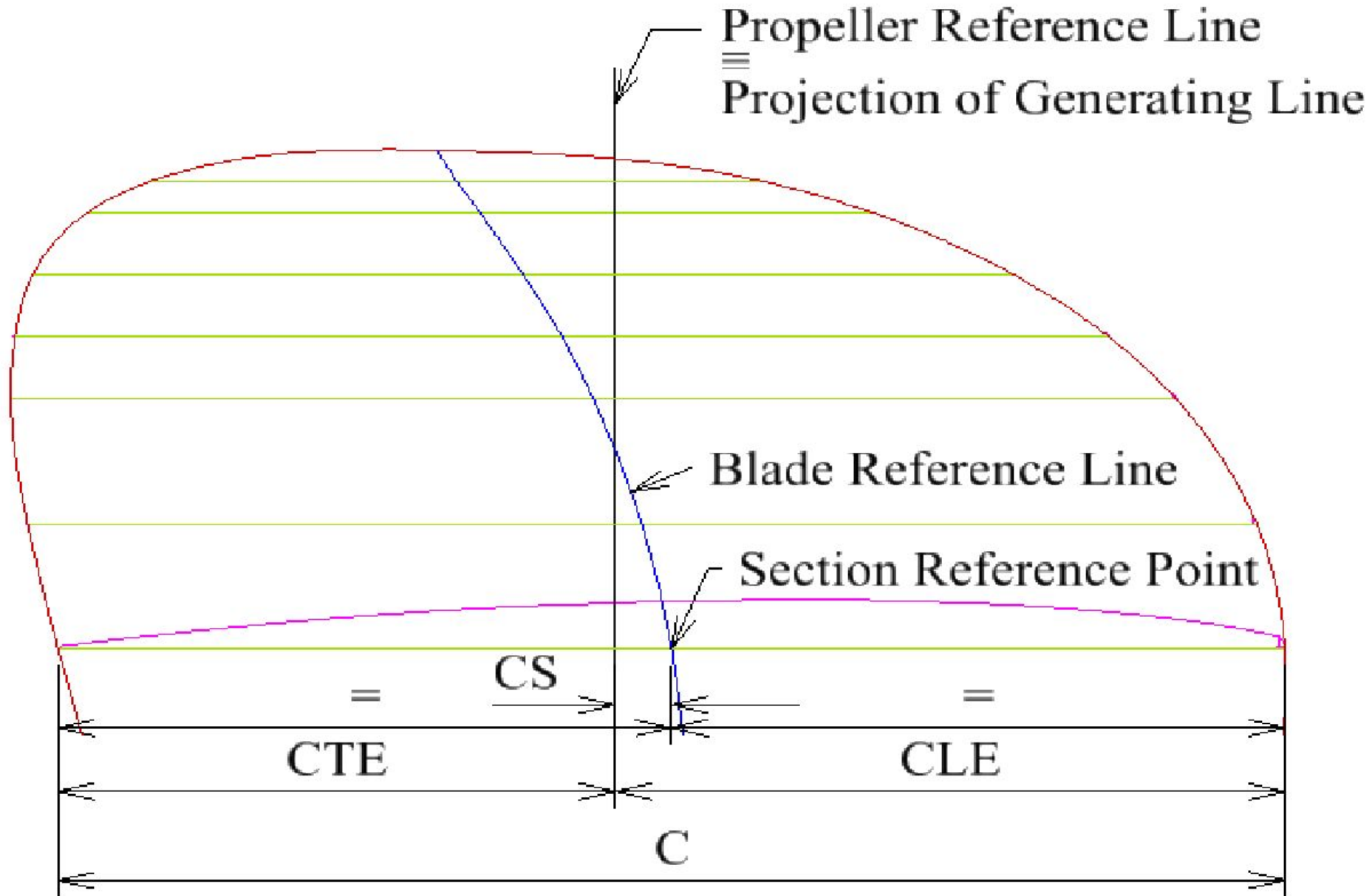
## Распределение профилей по радиусу винта



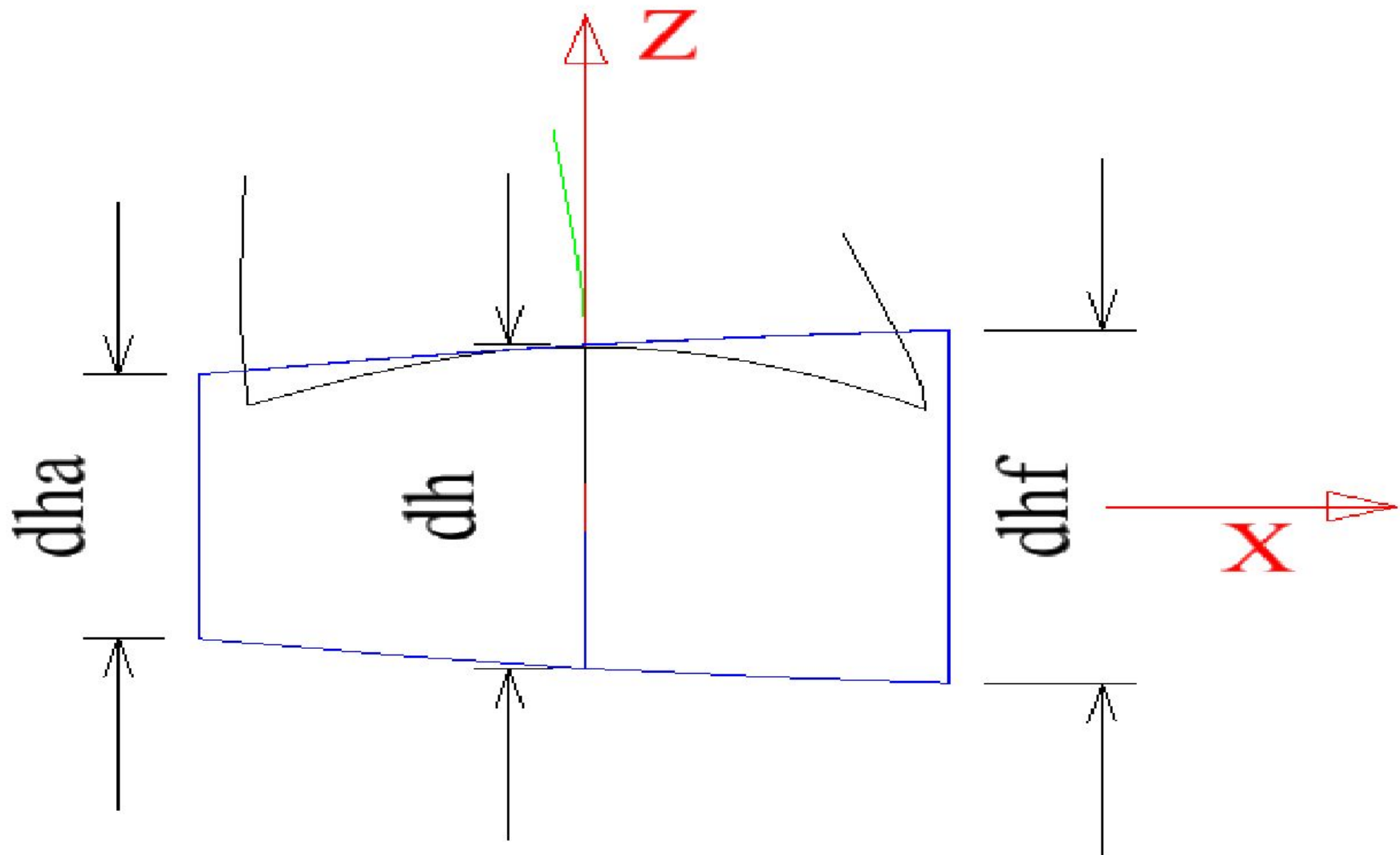






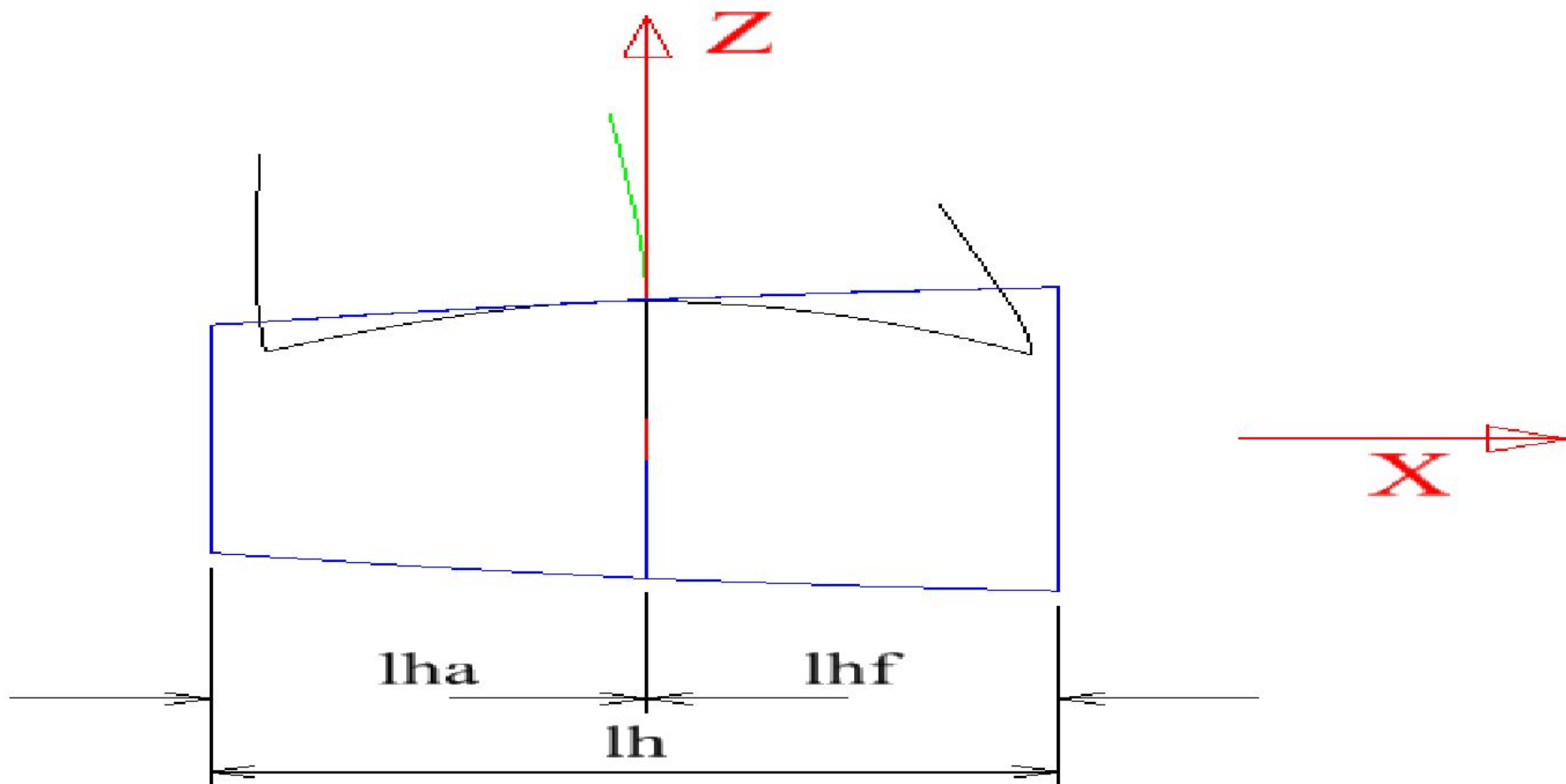


# Диаметры ступицы

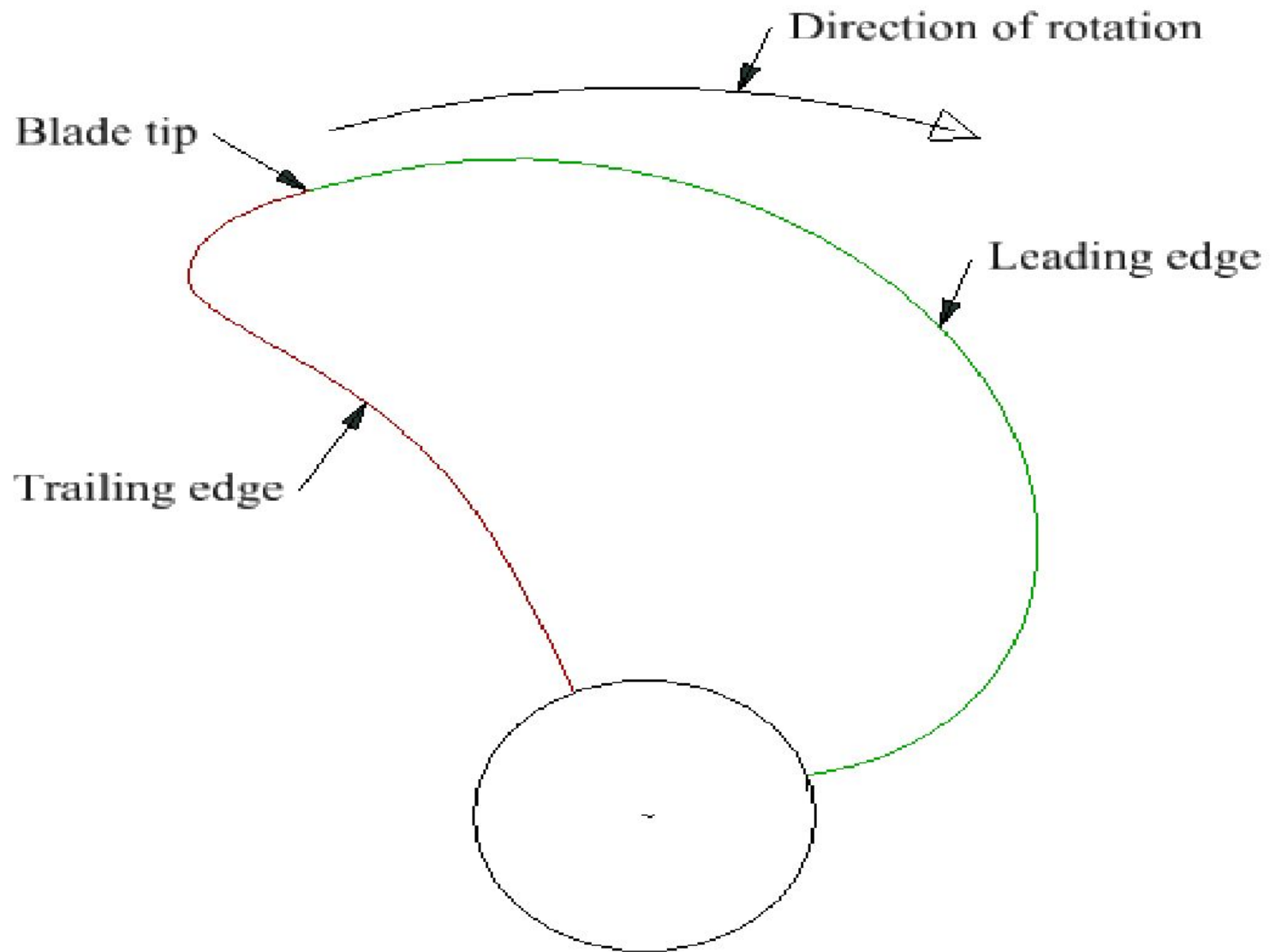




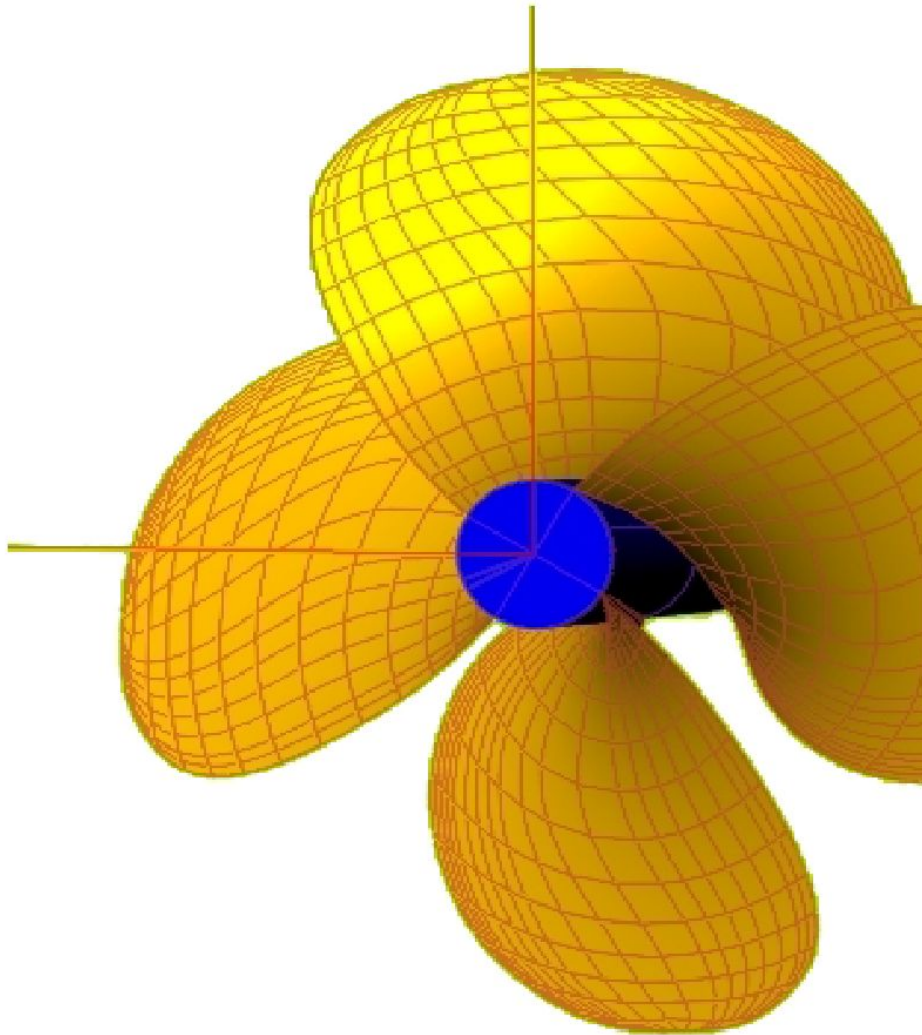
# Продольные размеры ступицы



# Входящая и выходящая кромки лопасти винта



# Screw propeller (Поверхность винта)



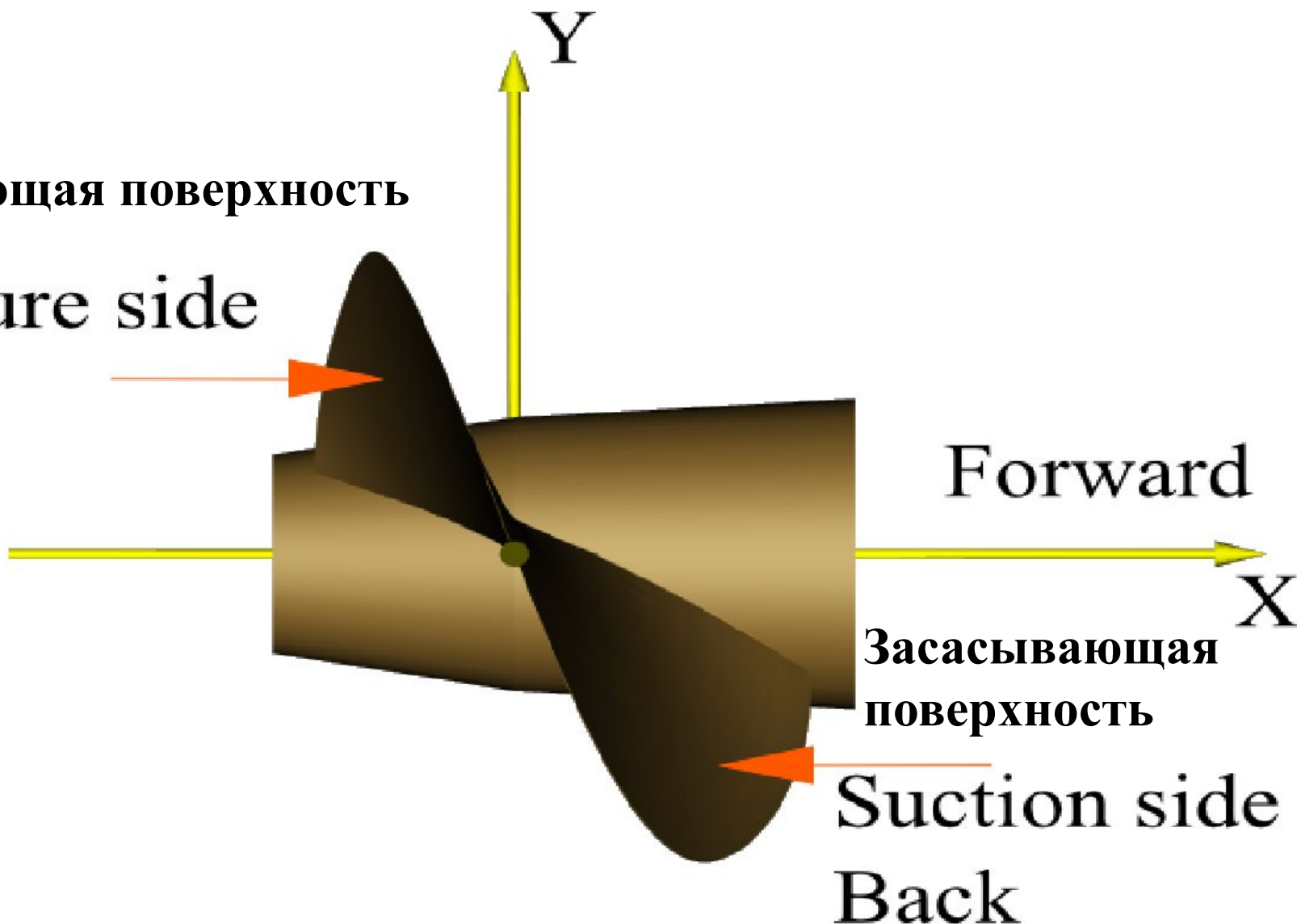


# Поверхности гребного винта

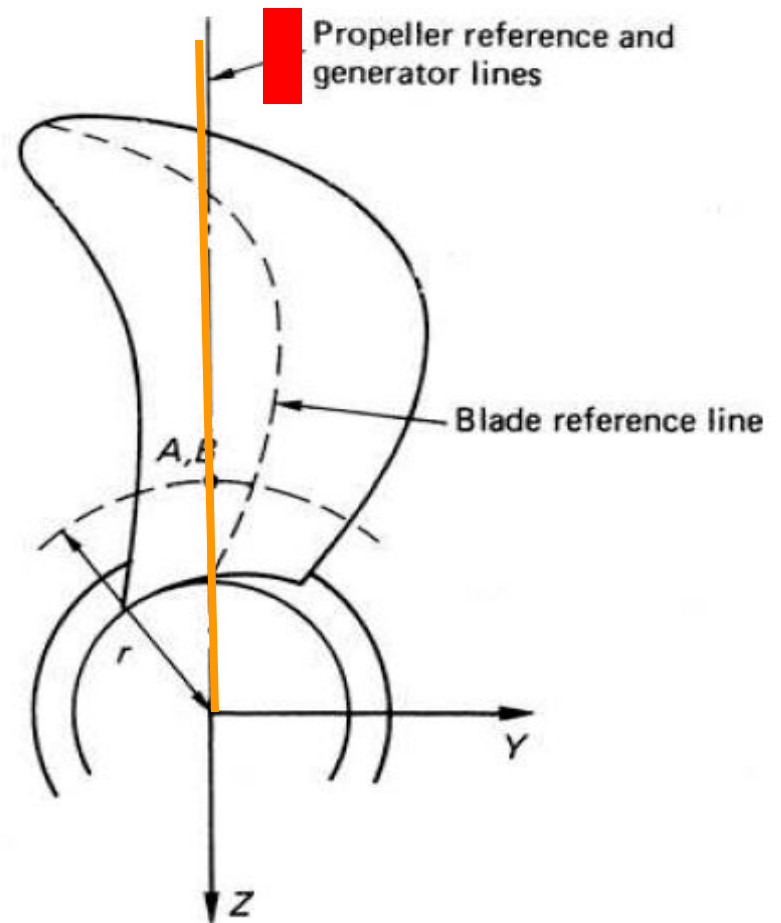
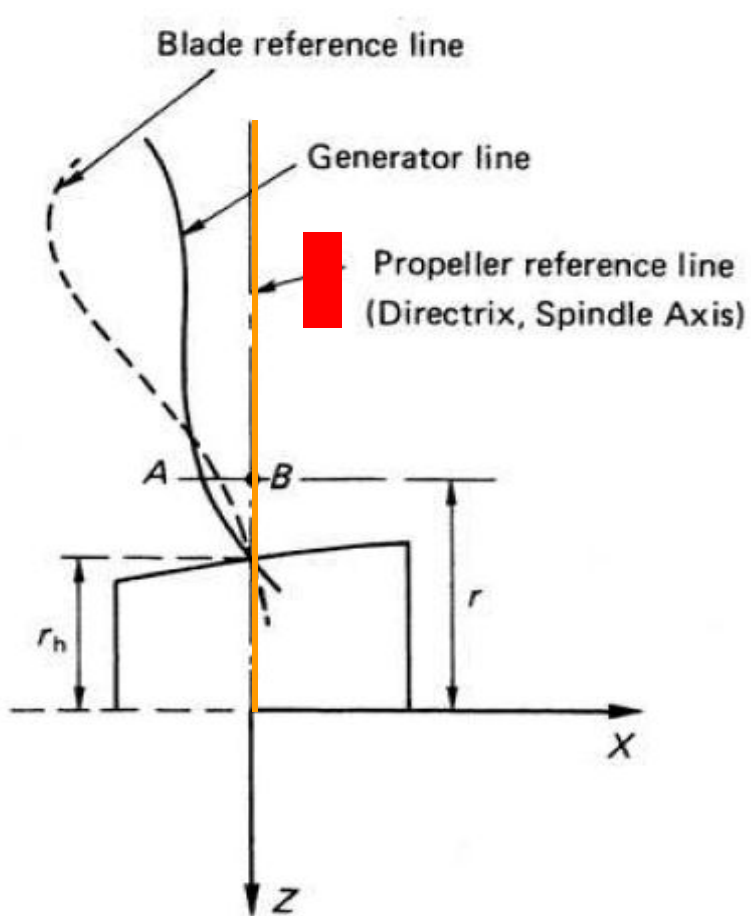
Нагнетающая поверхность

Pressure side

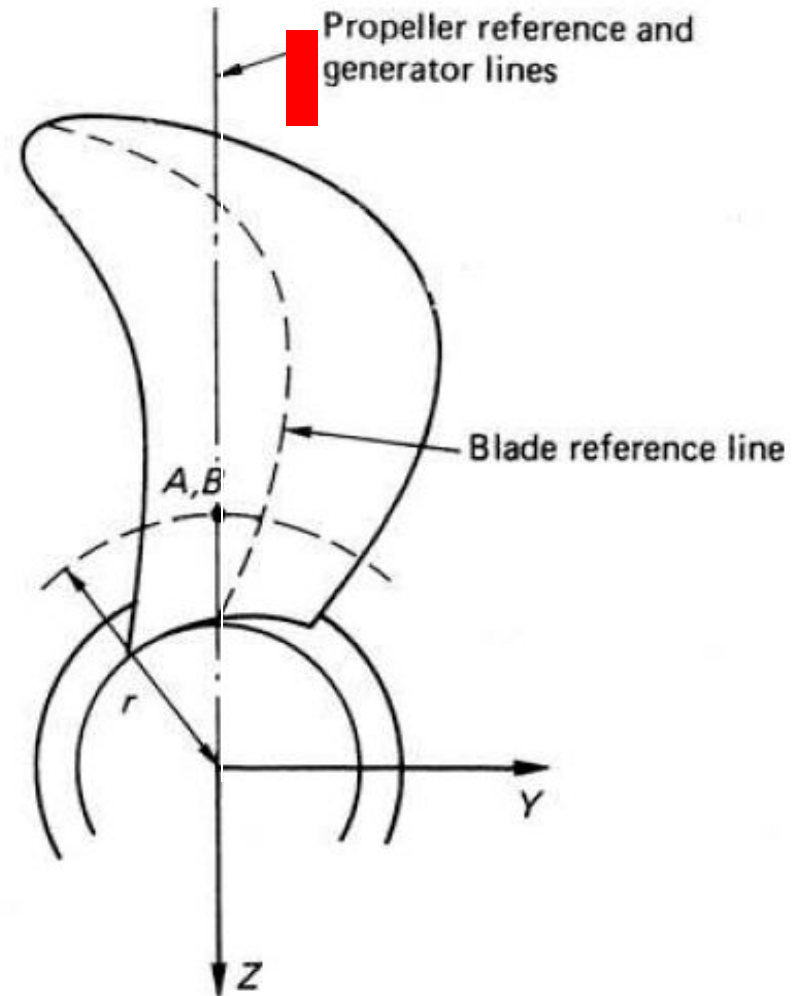
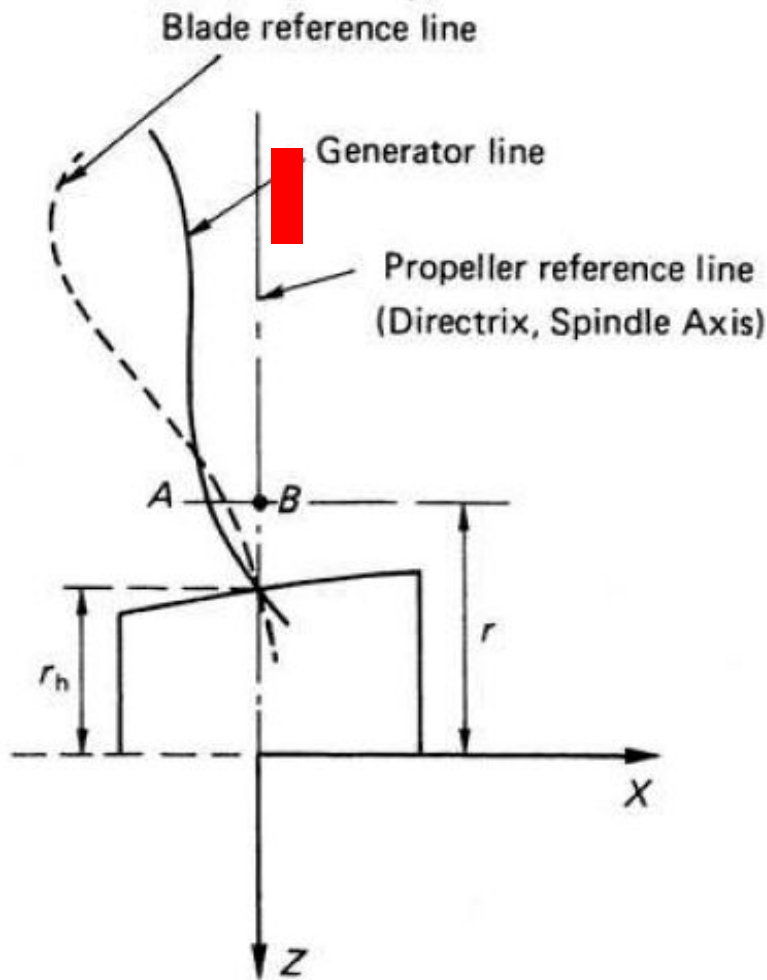
Face



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

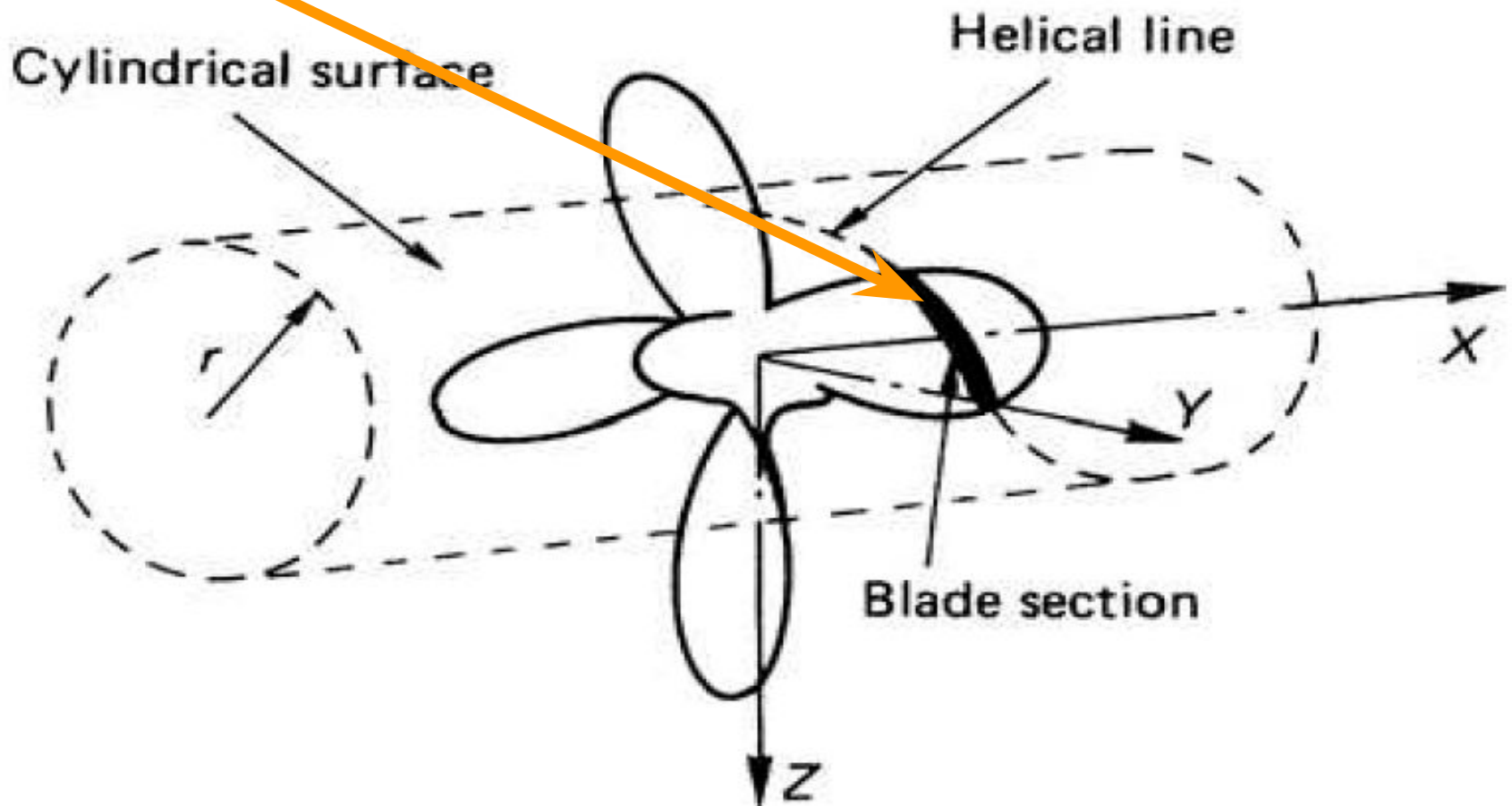


- **Generator line:** The line formed by intersection of the pitch helices and the plane containing the shaft axis and propeller reference line.
- **Образующая** – линия пересечения номинальной винтовой поверхности продольной плоскостью **XZ**

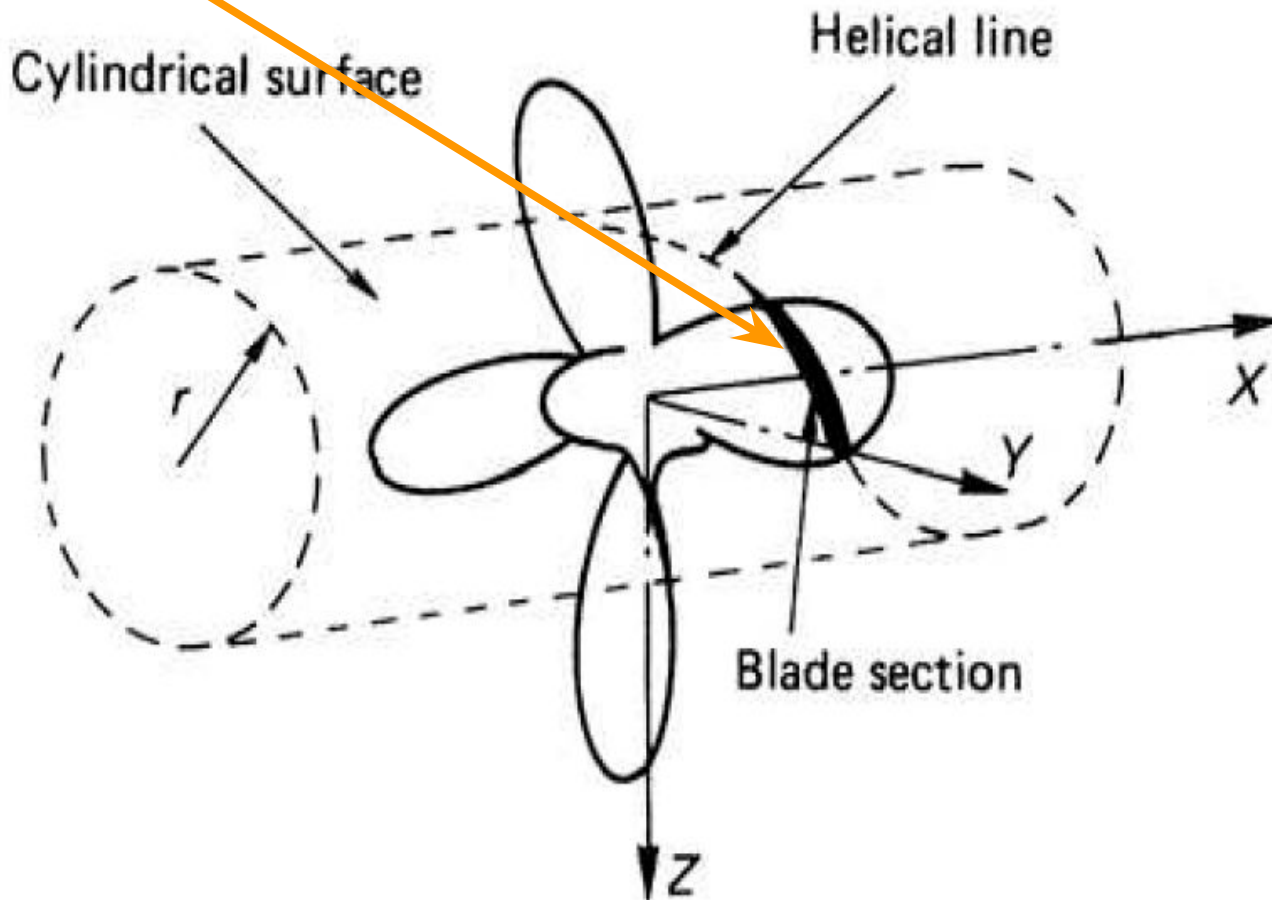




- The aerofoil sections which together comprise the blade of a propeller are defined on the surfaces of cylinders whose axes are concentric with the shaft axis.
- Профили – сечения лопасти соосными цилиндрами

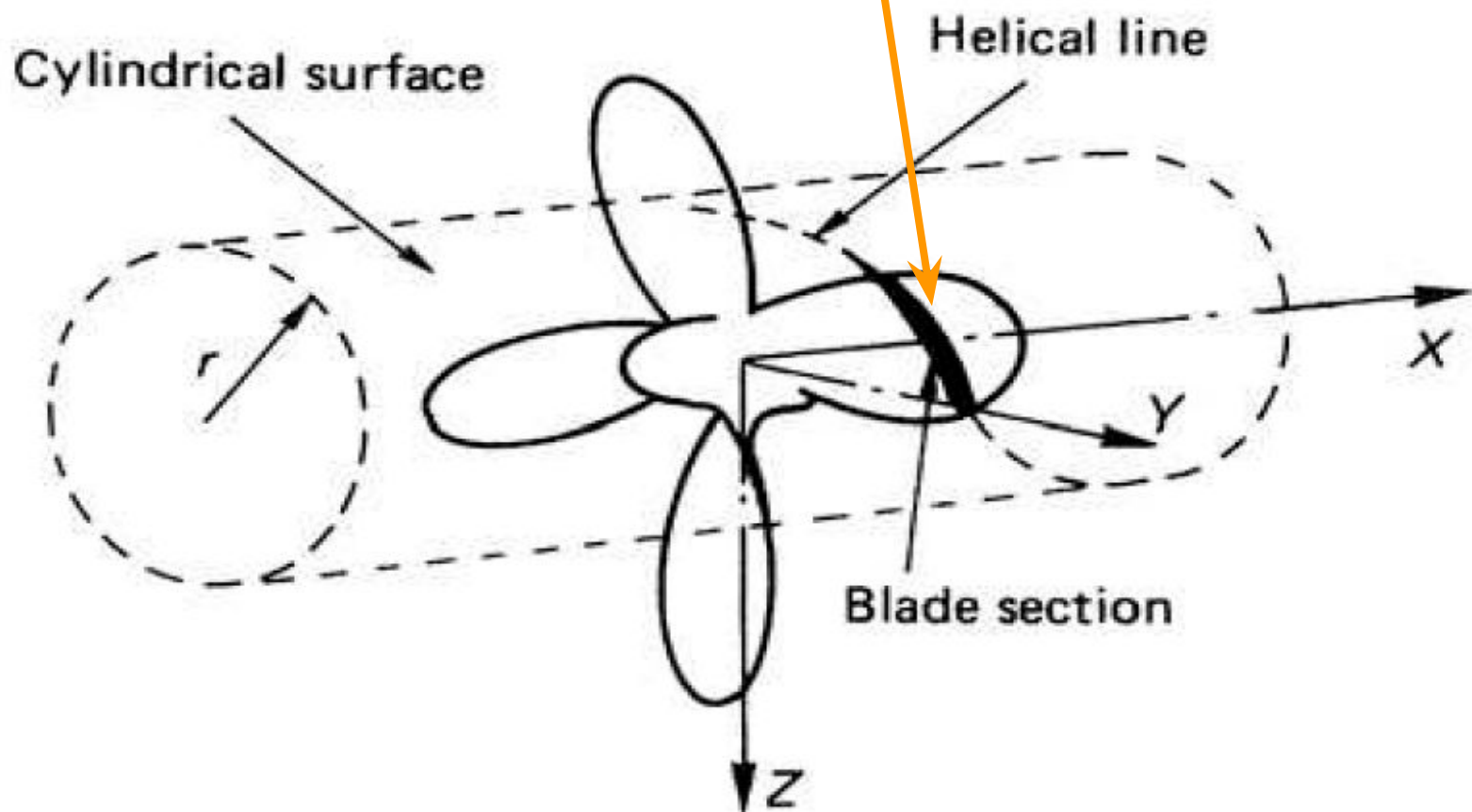


- **Face:** The side of a propeller blade which faces downstream during ahead motion is called face or pressure side (when viewed from aft of a ship to the bow the seen side of a propeller blade is called face or pressure side).
- **Нагнетающая поверхность**



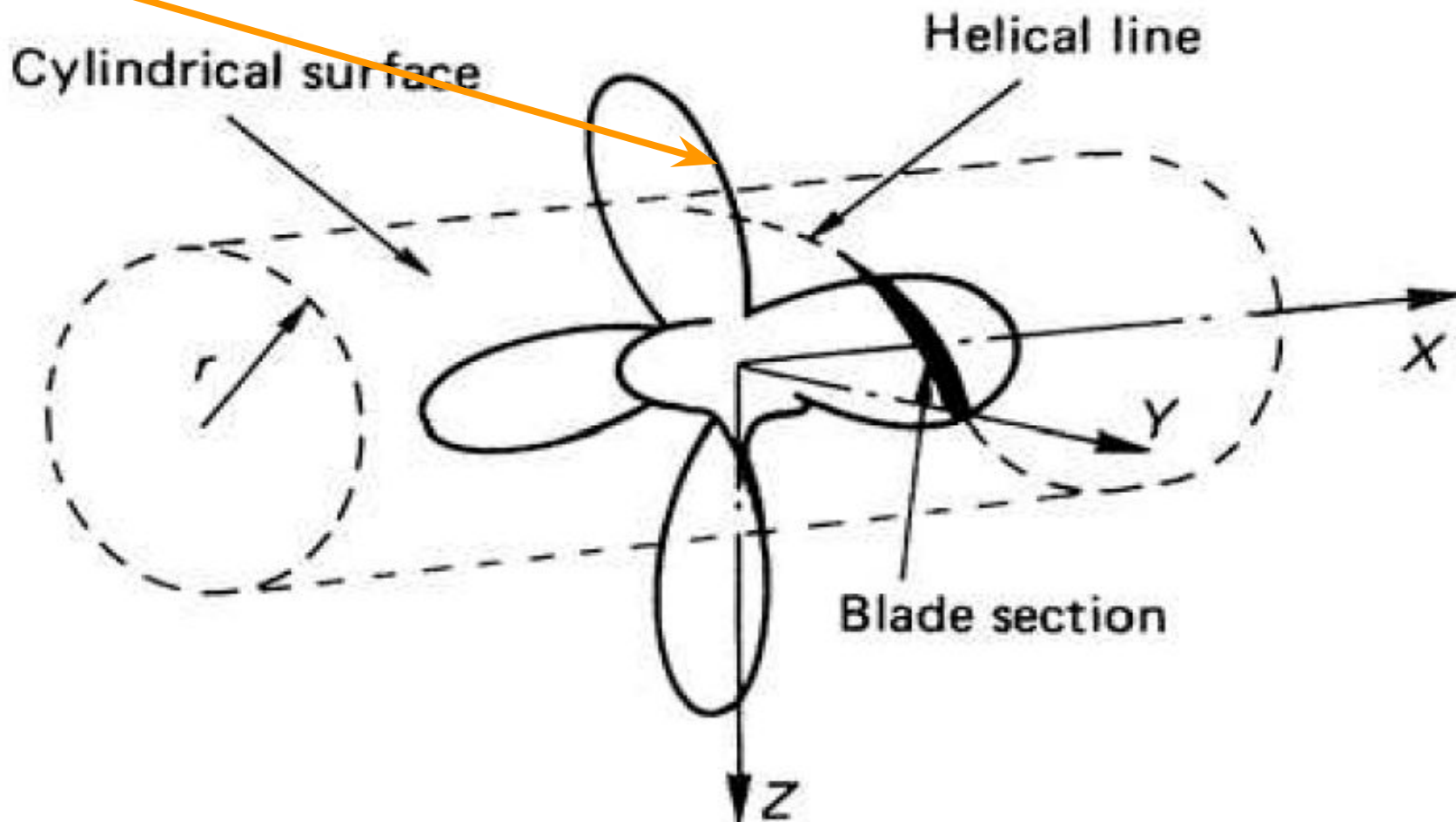
- **Back:** The side of a propeller blade which faces generally direction of ahead motion is called back or suction side (when viewed from aft of a ship to the bow the unseen side of a propeller blade is called back or suction side).

- **Засасывающая поверхность**

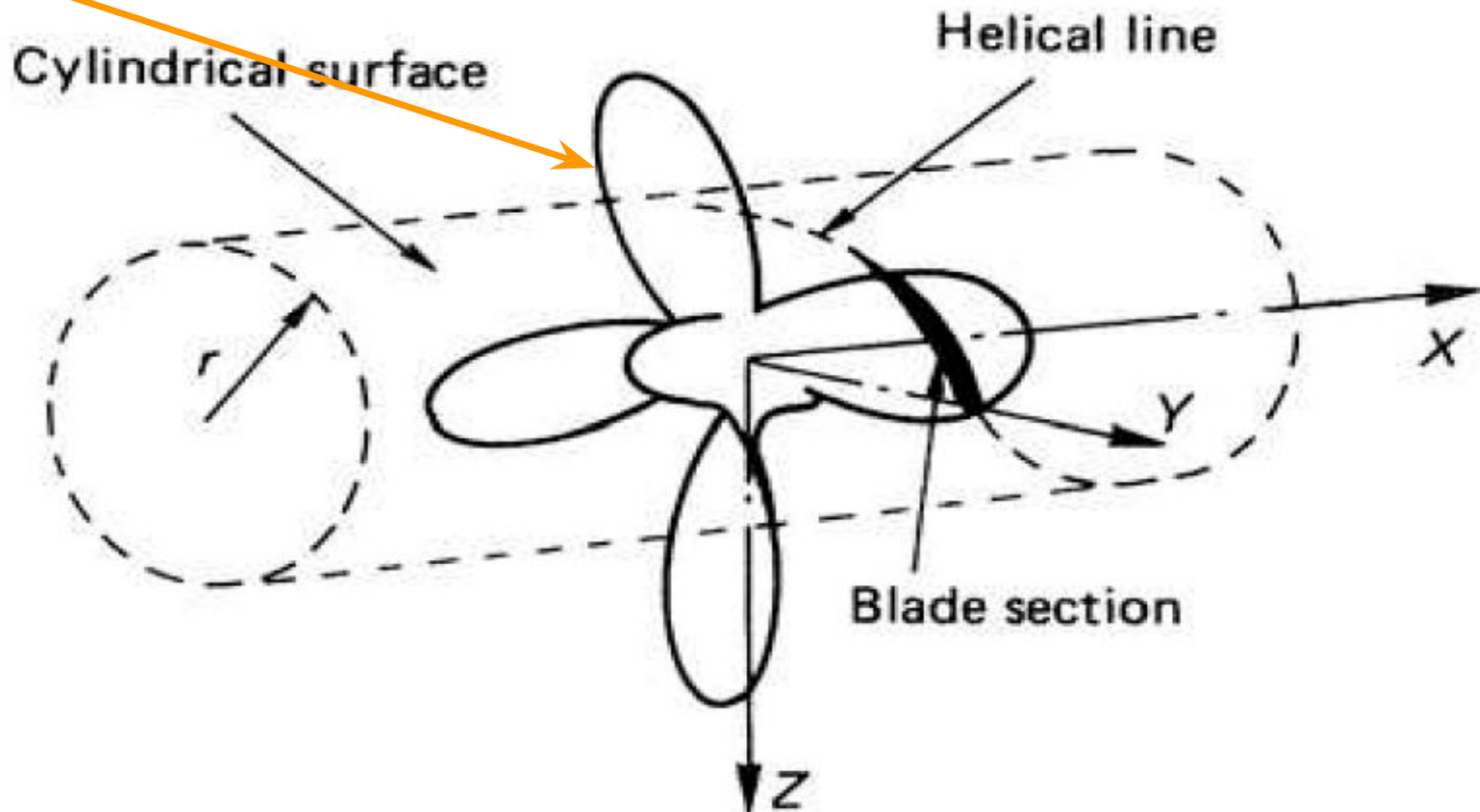




- **Leading Edge:** When the propeller rotating the edge piercing water is called leading edge.
- **Кромка, первой входящая в воду, называется входящей**



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



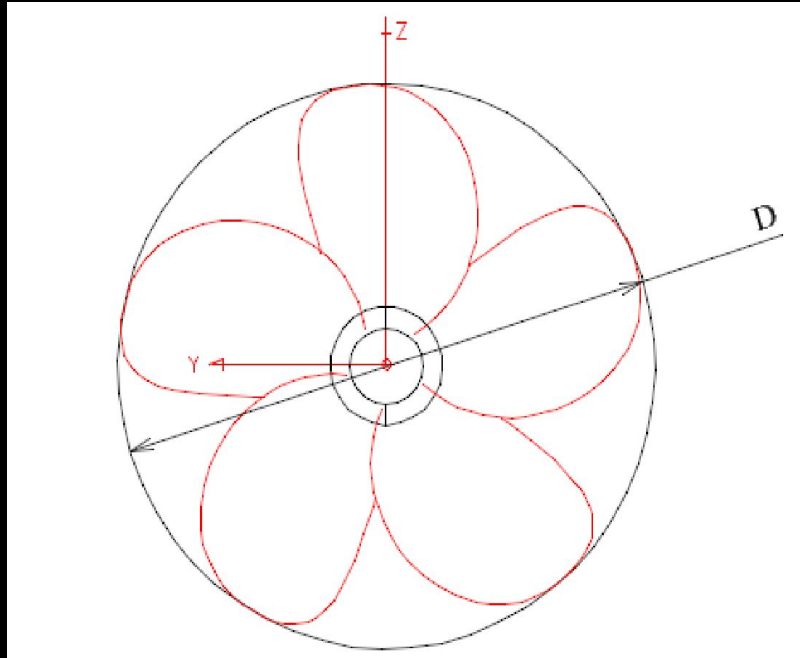
A large, reddish-brown propeller is shown in a workshop or dry dock. A person wearing a white protective suit is crouching on the propeller's hub to provide a sense of scale. The propeller has two large blades. The background shows a concrete floor and some industrial equipment.

Suction side

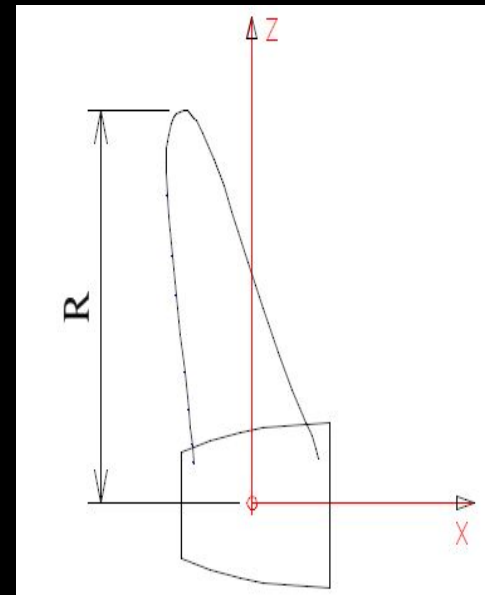
Pressure side



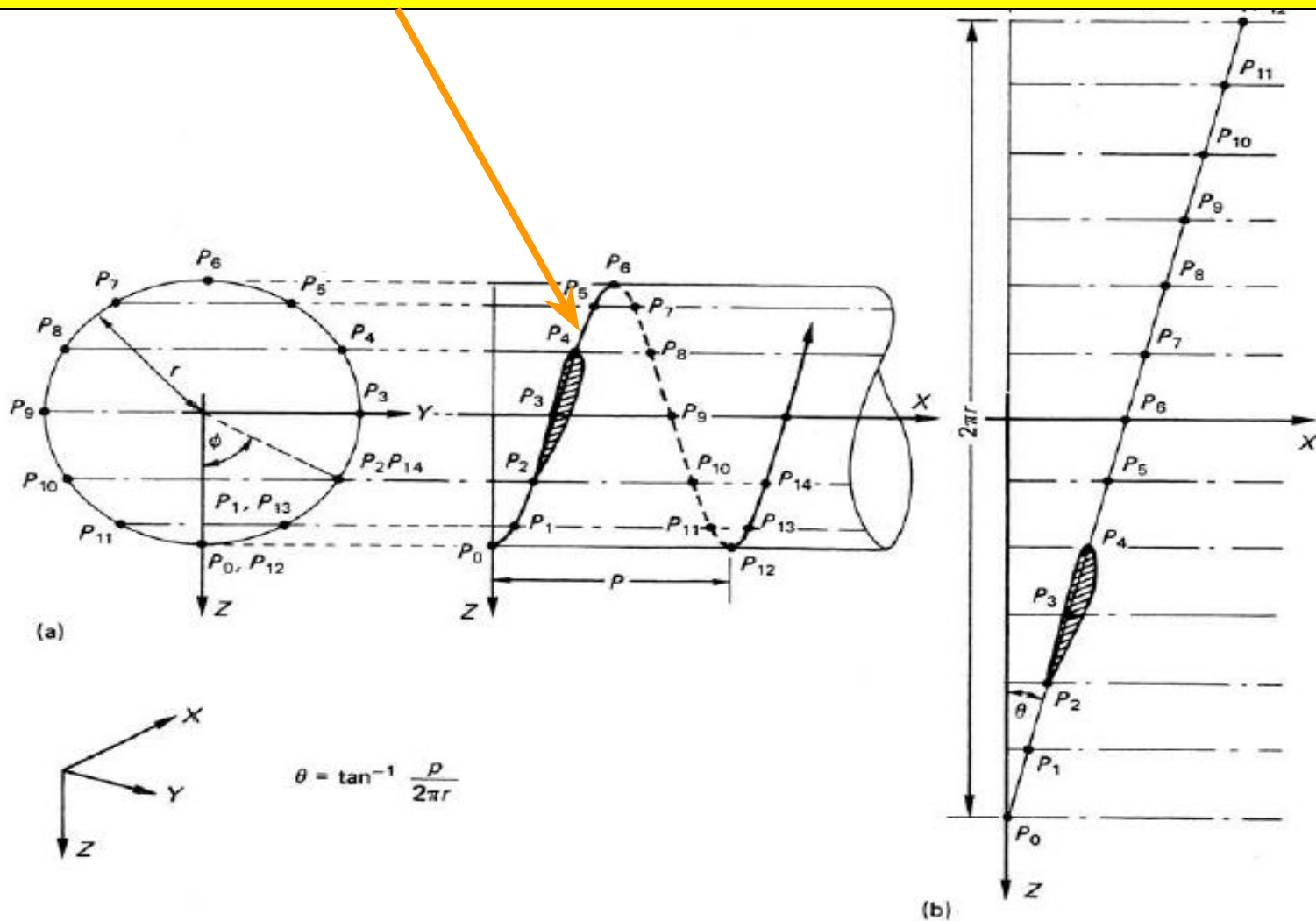
## Propeller disk, looking forward (Диск винта)



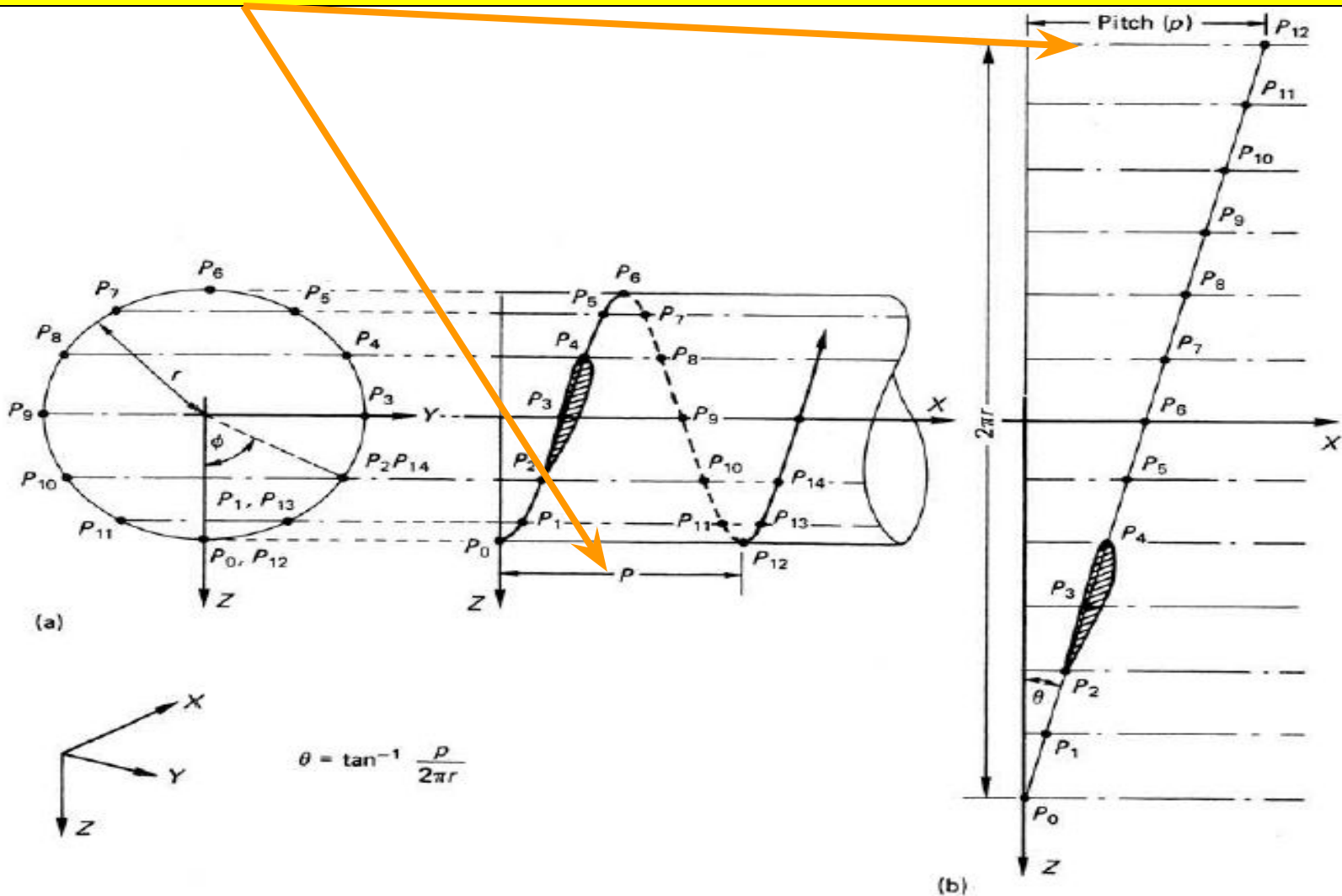
## Propeller radius Радиус винта



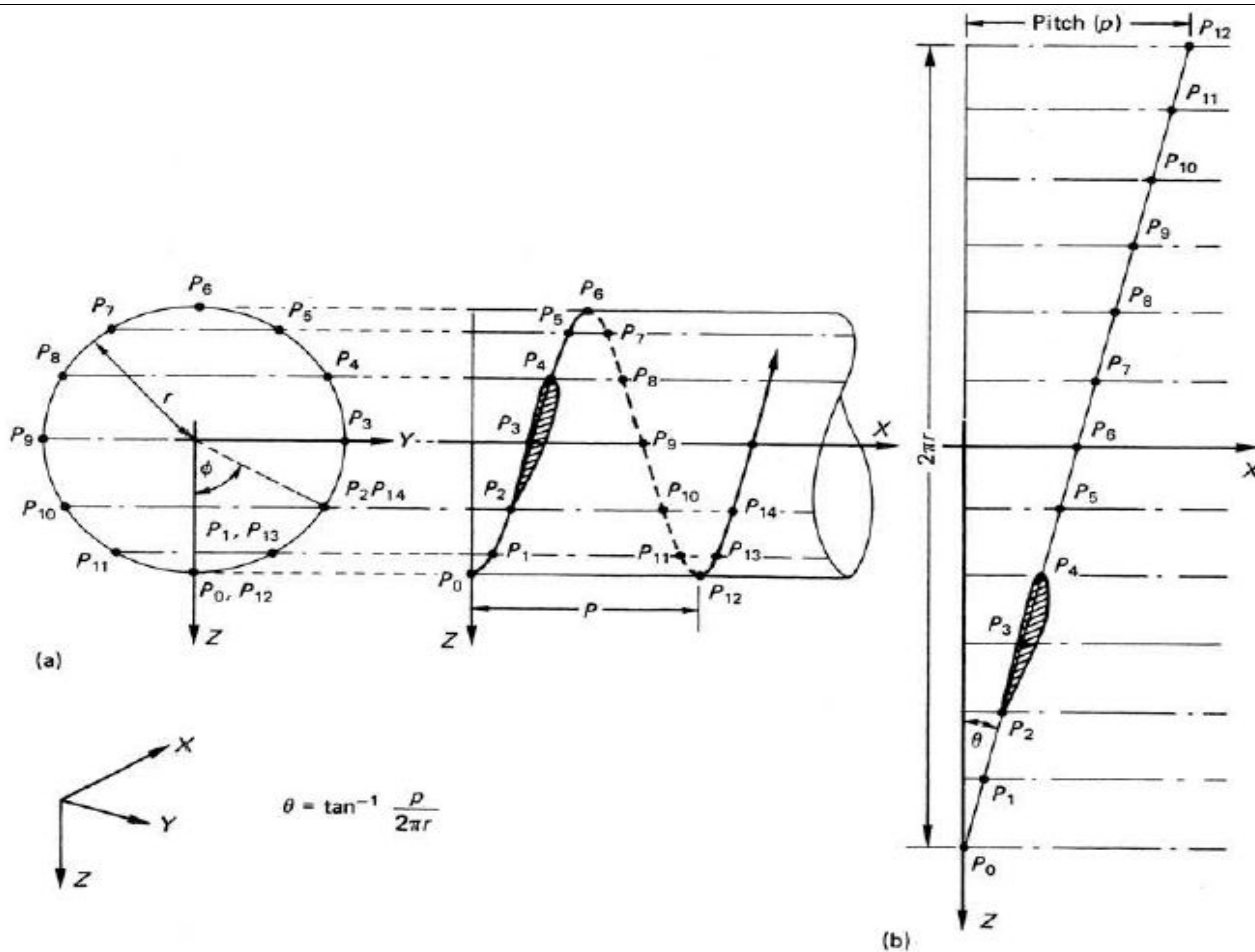
- Если точка  $P$ , лежащая на поверхности цилиндра радиуса  $r$  начнет одновременно двигаться вдоль оси  $X$  от начальной точки  $P_0$  и вращаться вокруг этой оси, то получим цилиндрическую спираль.



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



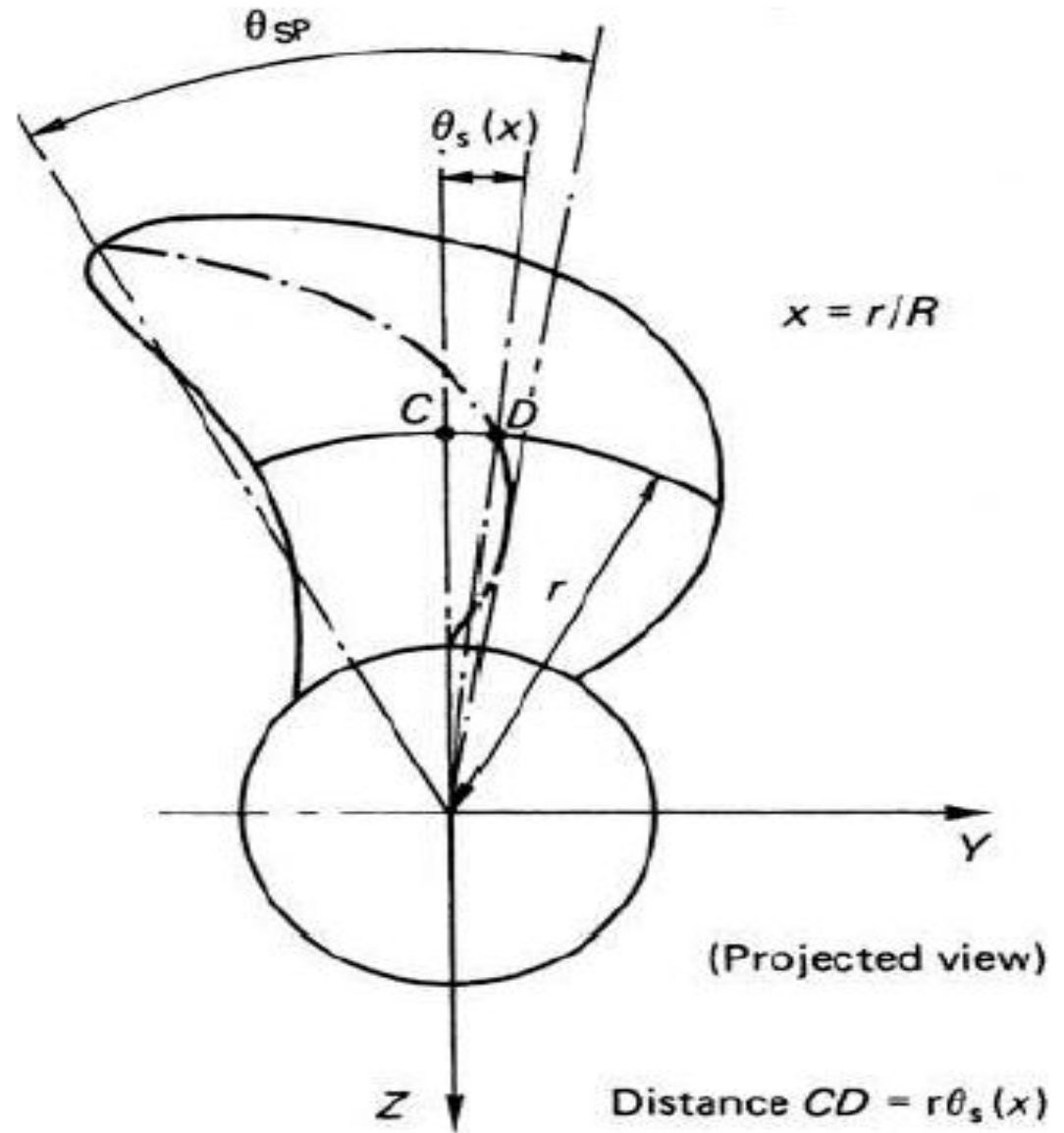
- **Шаговый угол:**
- The distance moved forward by the helical line during this revolution is P and the helix angle is given by:



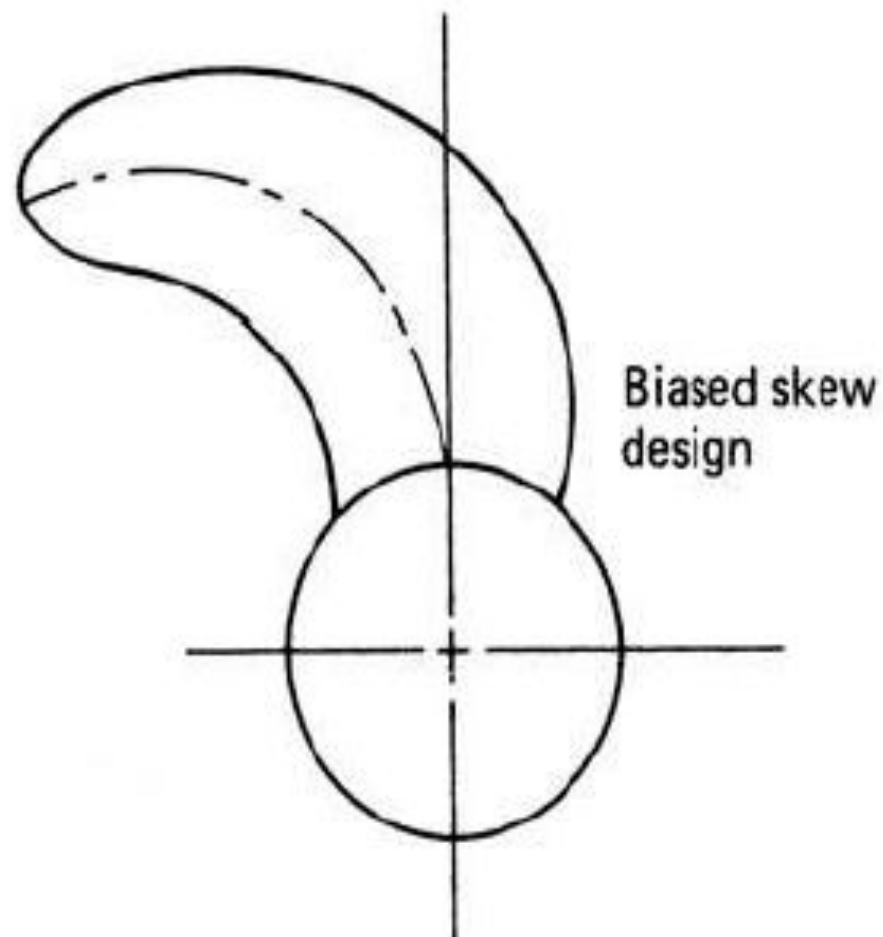
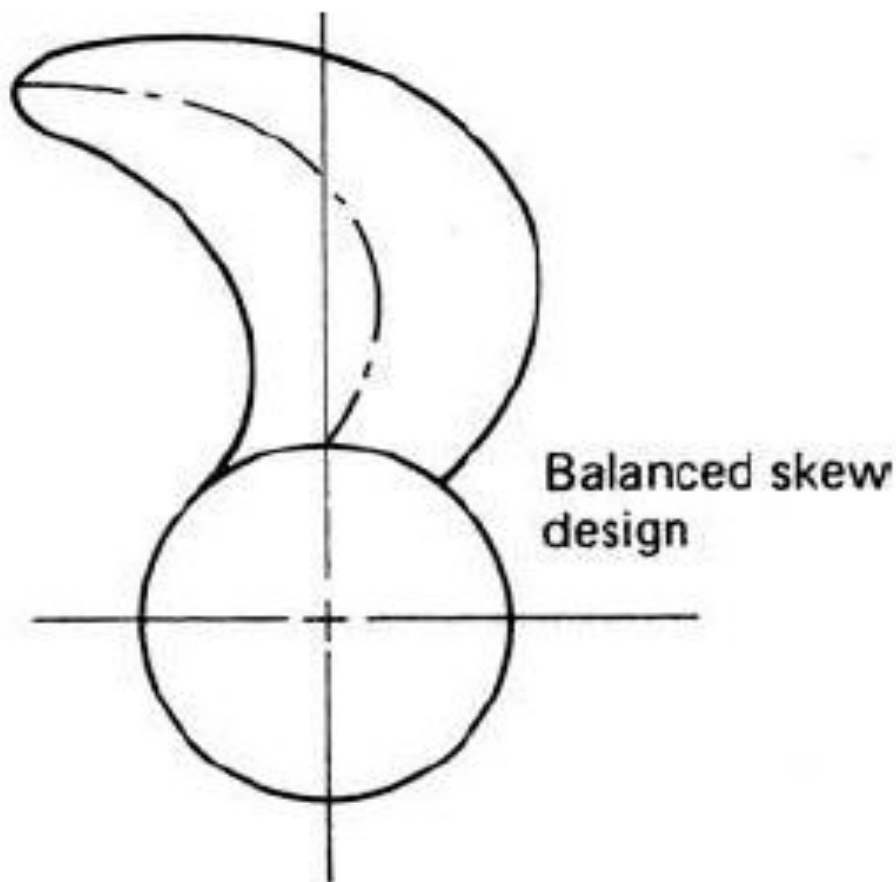
$$\theta = \tan^{-1} \left( \frac{p}{2\pi r} \right)$$



- Skew/  
**САБЛЕВИДНОСТЬ**
- It is the angle between the mid-chord position of a section and the directrix ( $\theta_s$ ).
- The propeller skew angle ( $\theta_{sp}$ ) 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



# Саблевидные гребные винты

## Лопастей разной саблевидности

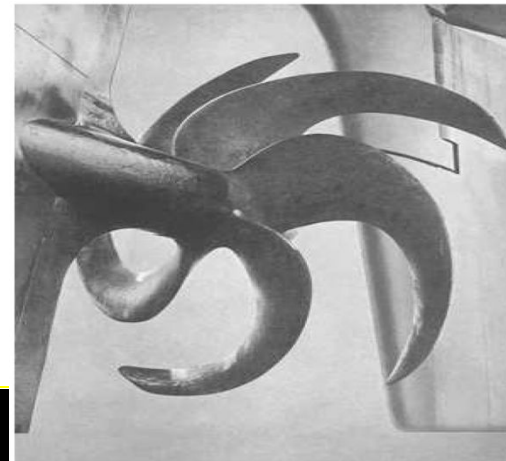


### Преимущества

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

### Недостатки

- Дорогие!
- Менее эффективны
- при реверсе

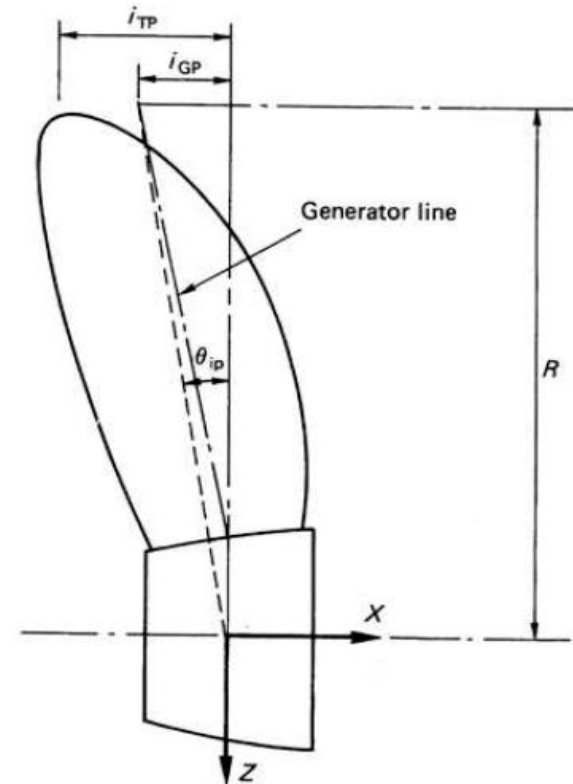
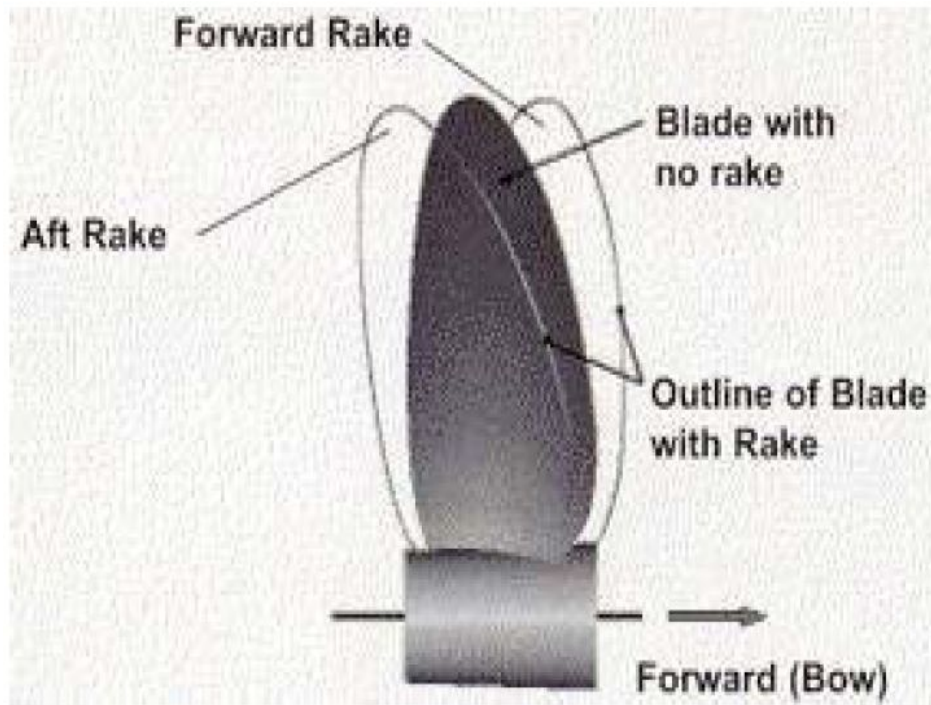


DDG51

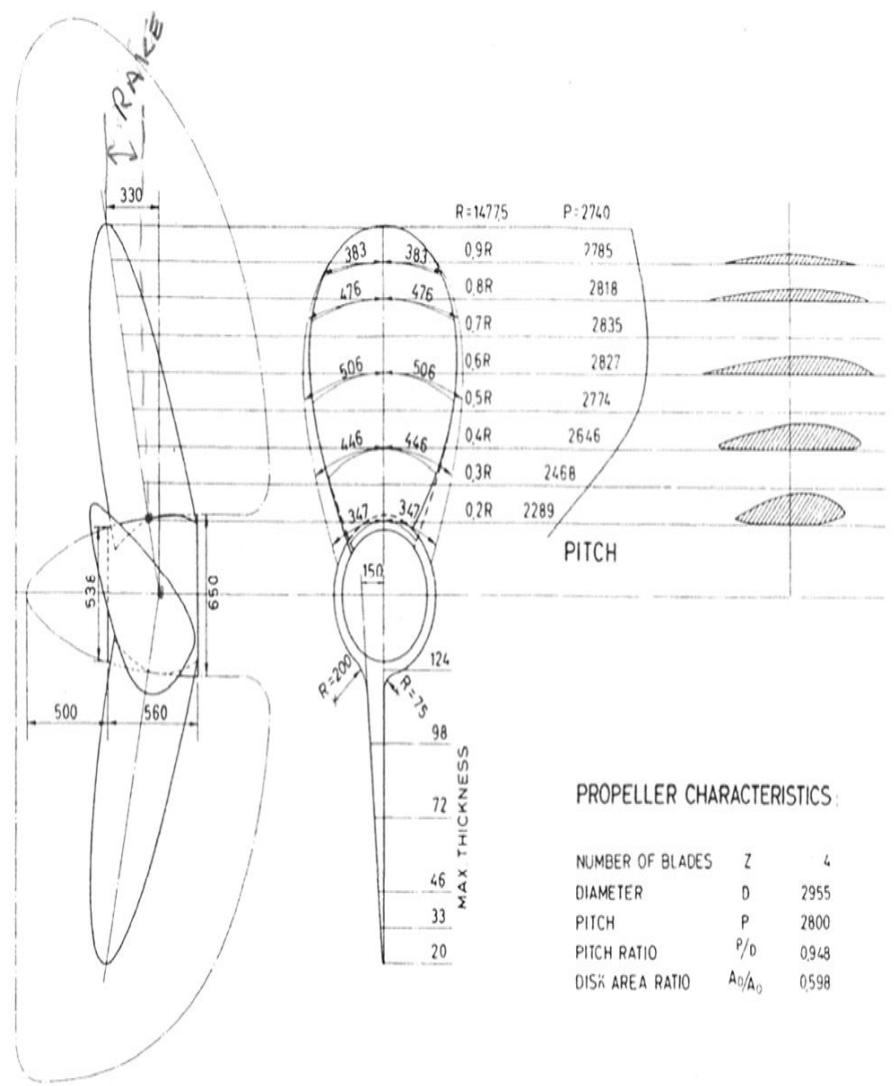
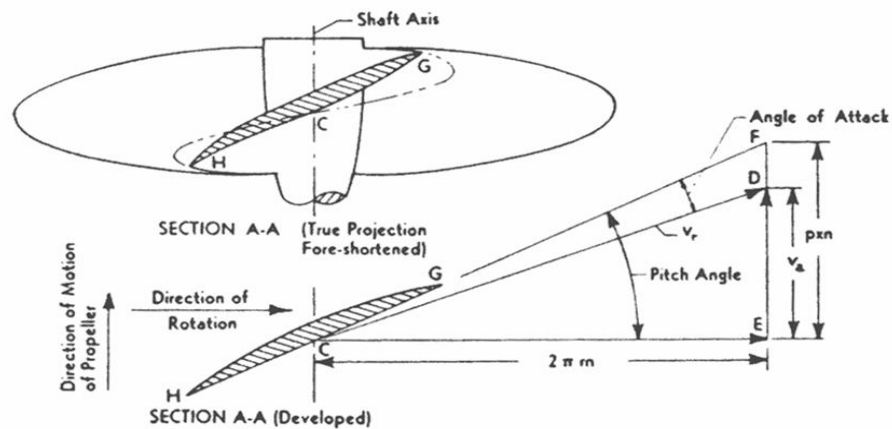
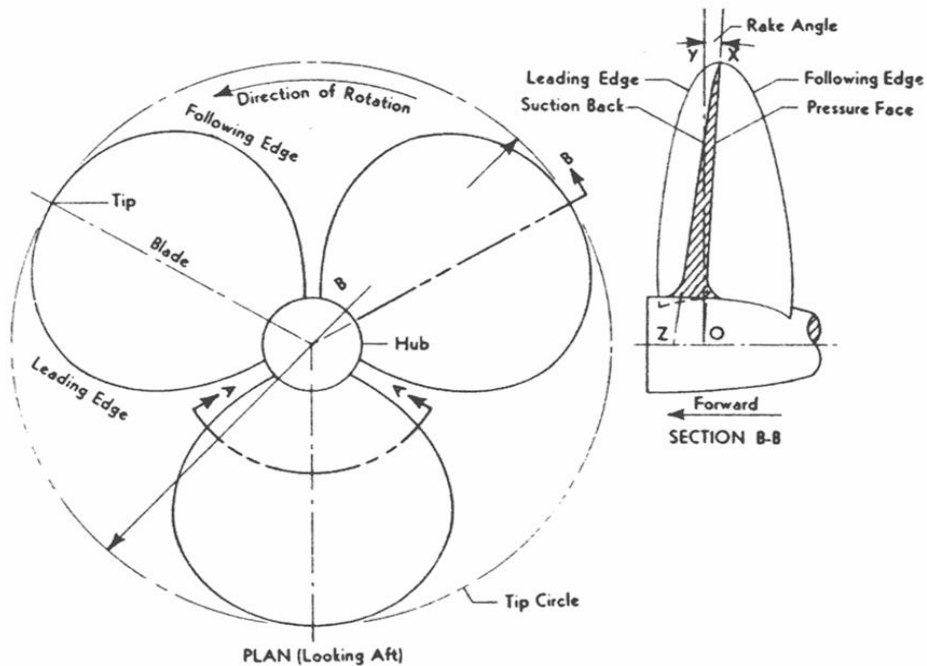
- The displacement from the propeller plane to the generator line in the direction of the shaft axis is called **rake (Наклон лопасти)**. The propeller rake is divided into two components: generator line rake and skew induced rake.

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

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







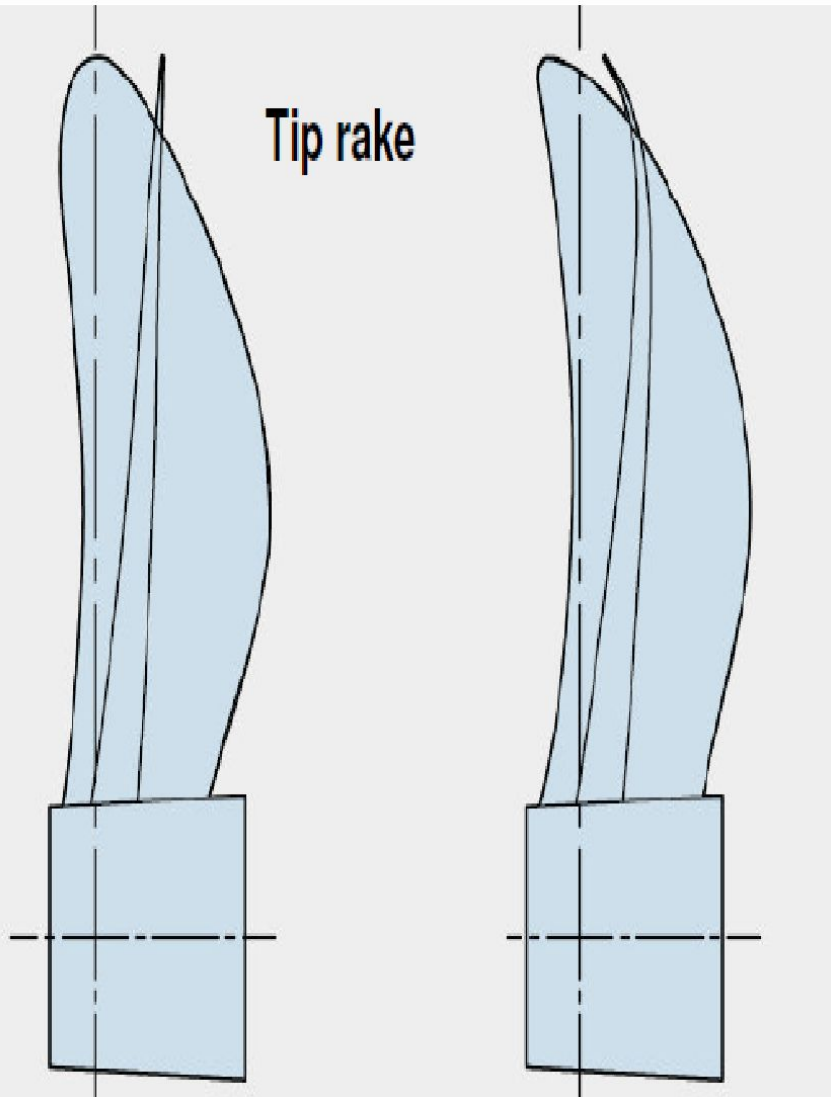
Propeller Geometry Definitions

PROPELLER CHARACTERISTICS:

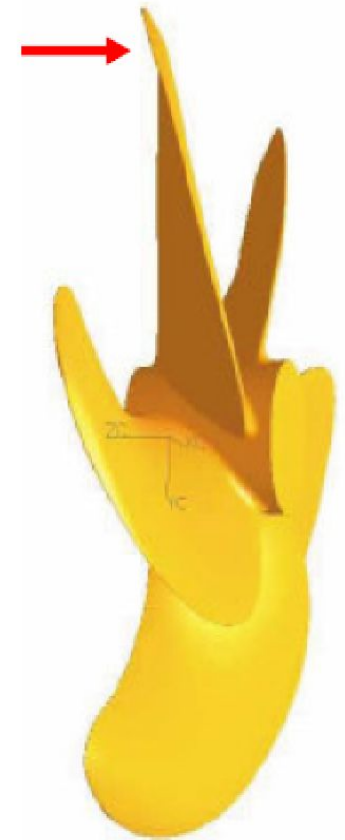
|                  |           |       |
|------------------|-----------|-------|
| NUMBER OF BLADES | Z         | 4     |
| DIAMETER         | D         | 2955  |
| PITCH            | P         | 2800  |
| PITCH RATIO      | P/D       | 0.948 |
| DISK AREA RATIO  | $A_0/A_D$ | 0.598 |

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

# Загиб края лопасти

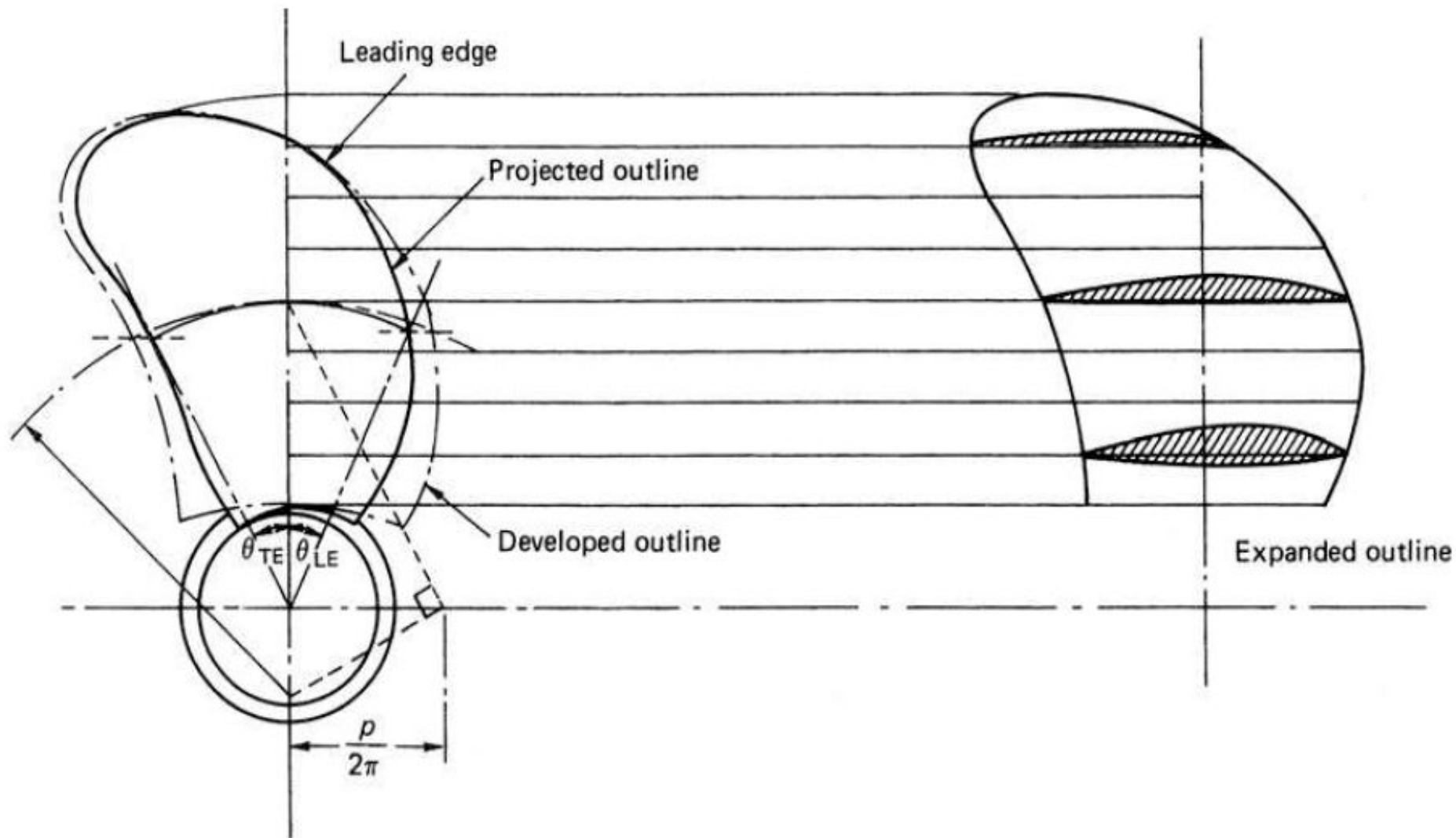


conventional  
propeller design



Lips tip rake  
propeller design

# • Контуры и площади



Expanded Area  $A_E$

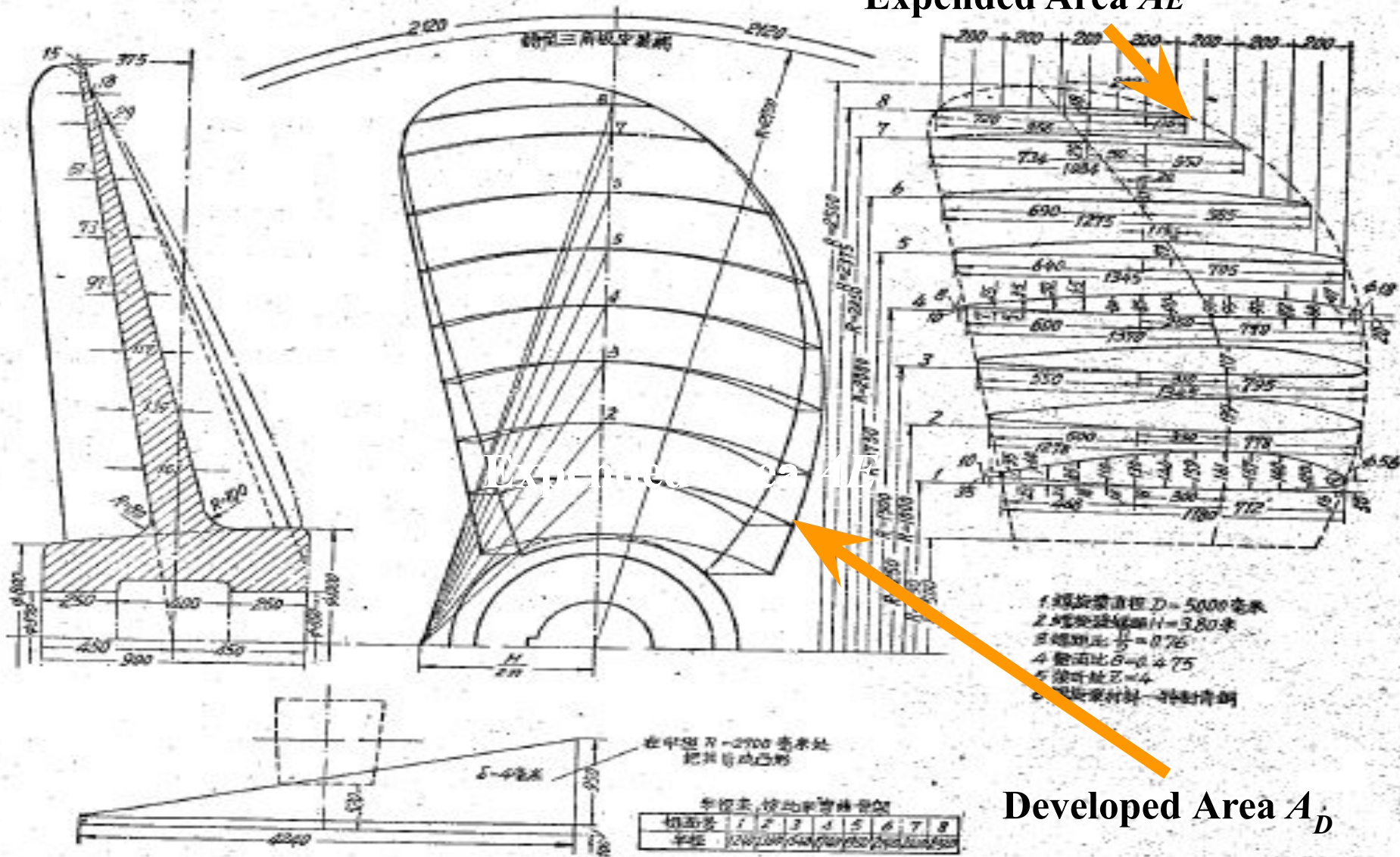


图 3-21

Developed Area  $A_D$



- 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 ( $A_E$ ) Спрямолинейная  
поверхность
- 5. Swept outline ( $A_s$ ) Ометаемая поверхность  
(диск винта за исключением проекции ступицы)

# Построение развернутой проекции вручную

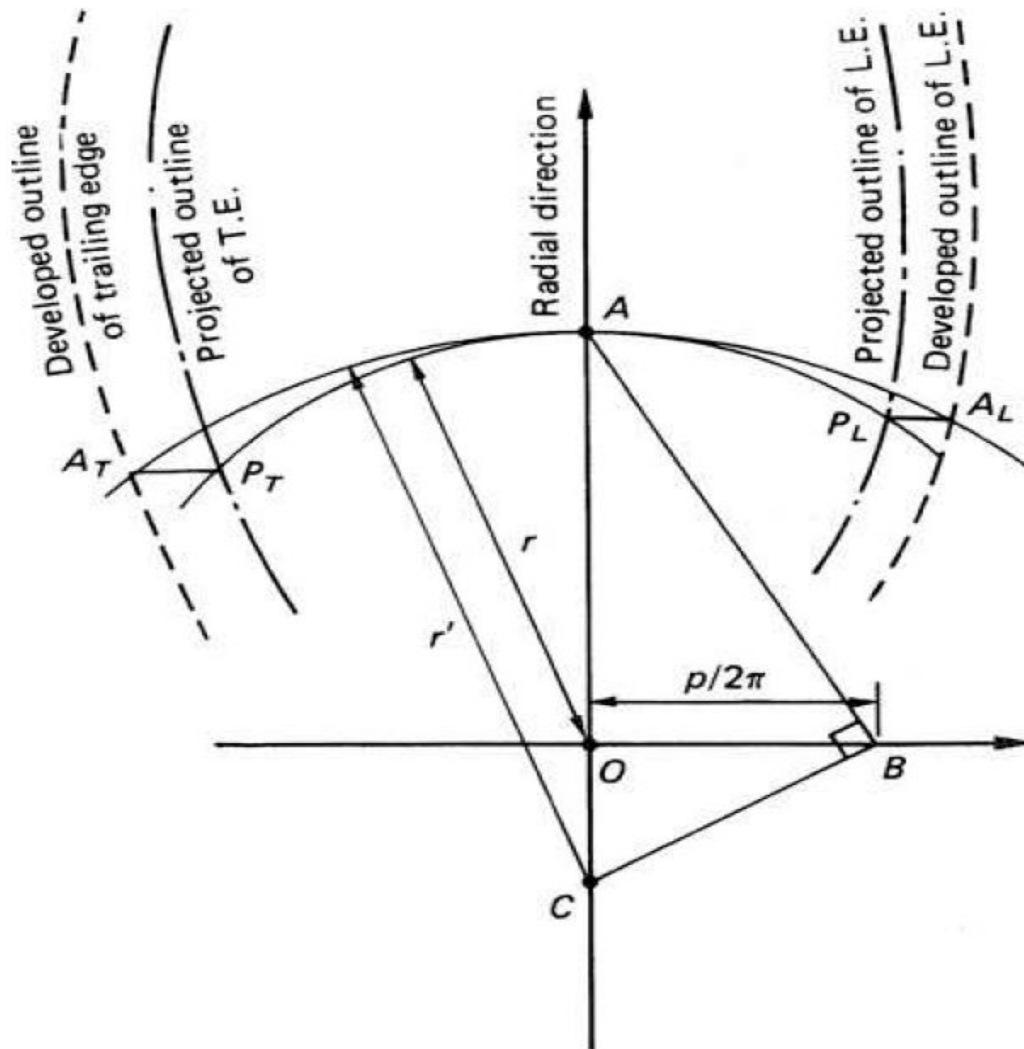
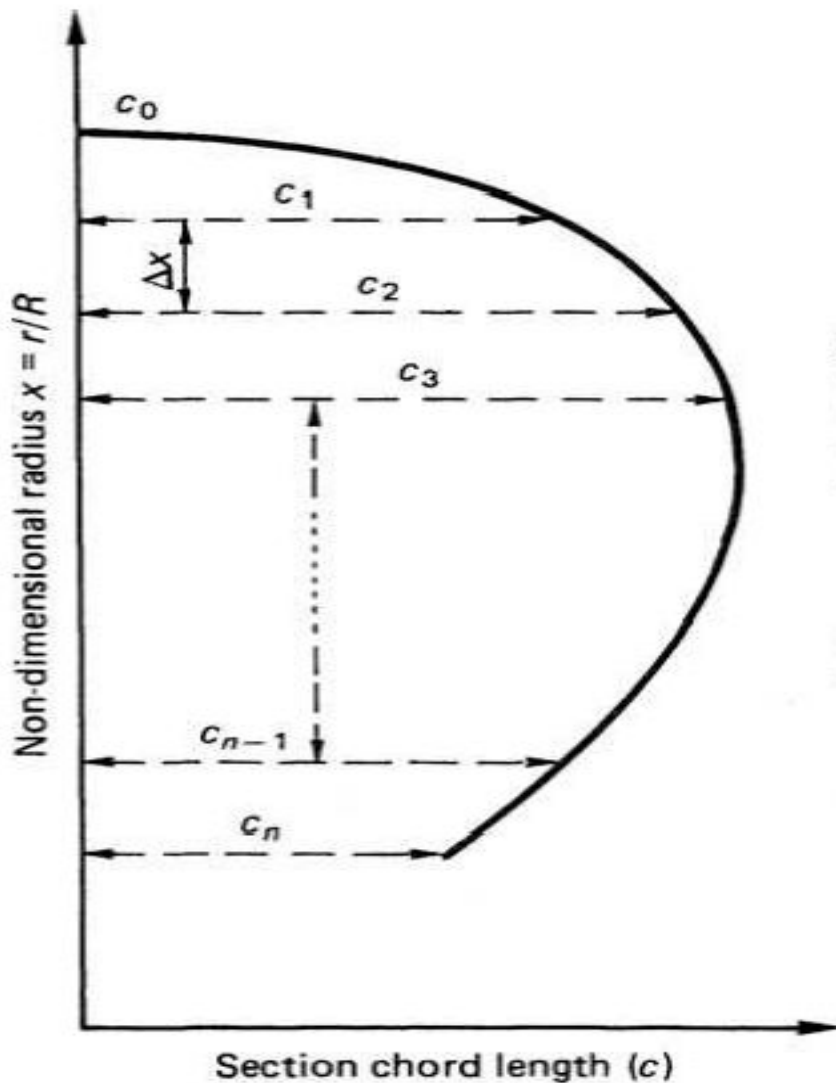


Figure 3.14 Holst's propeller drawing method

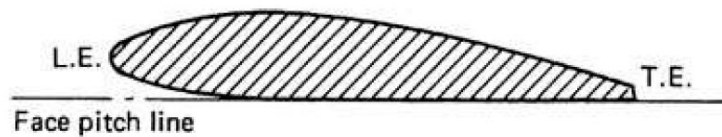
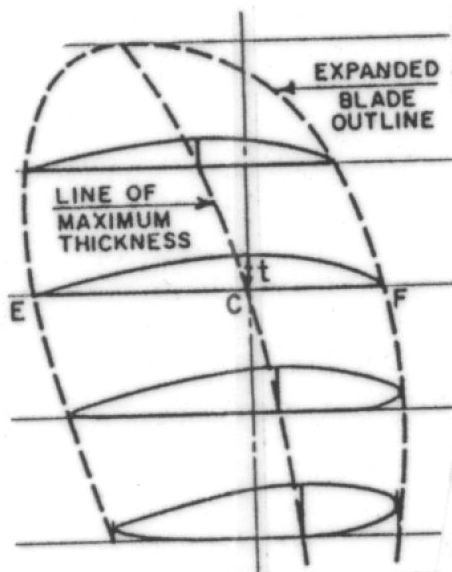
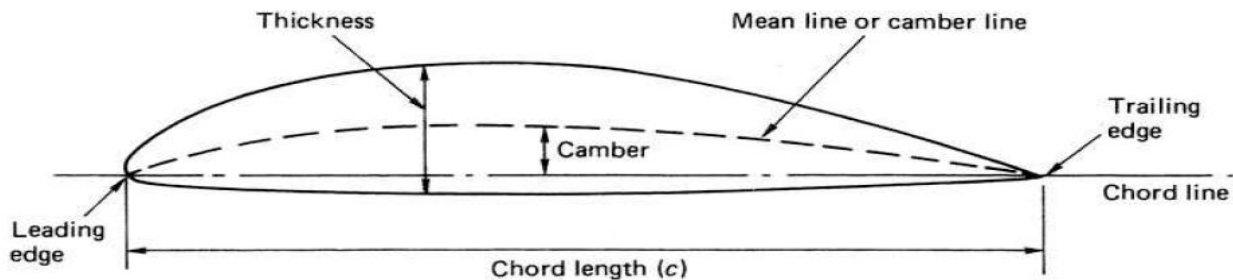
# ВЫЧИСЛЕНИЕ ПЛОЩАДИ АЕ



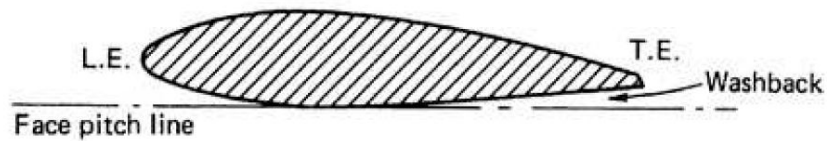
| $x$               | $c$       | SM  | $c \cdot SM$                                   |
|-------------------|-----------|-----|--|
| 1.00              | $c_0$     | 1/2 | $c_0/2$  |
| $1-\Delta x$      | $c_1$     | 2   | $2c_1$   |
| $1-2\Delta x$     | $c_2$     | 1   | $c_2$  |
| $1-3\Delta x$     | $c_3$     | 2   | $2c_3$   |
| ⋮                 | ⋮         | ⋮   | ⋮  |
| ⋮                 | ⋮         | ⋮   | ⋮  |
| $1-(n-1)\Delta x$ | $c_{n-1}$ | 2   | $2c_{n-1}$                                     |
| $1-n\Delta x$     | $c_n$     | 1/2 | $c_n/2$  |
|                   |           |     | <u><u><math>\Sigma (c \cdot SM)</math></u></u> |

$$\underline{\underline{A_E \simeq 0.667z \Delta x \Sigma (c \cdot SM)}}$$

# Построение профилей



(a)



(b)

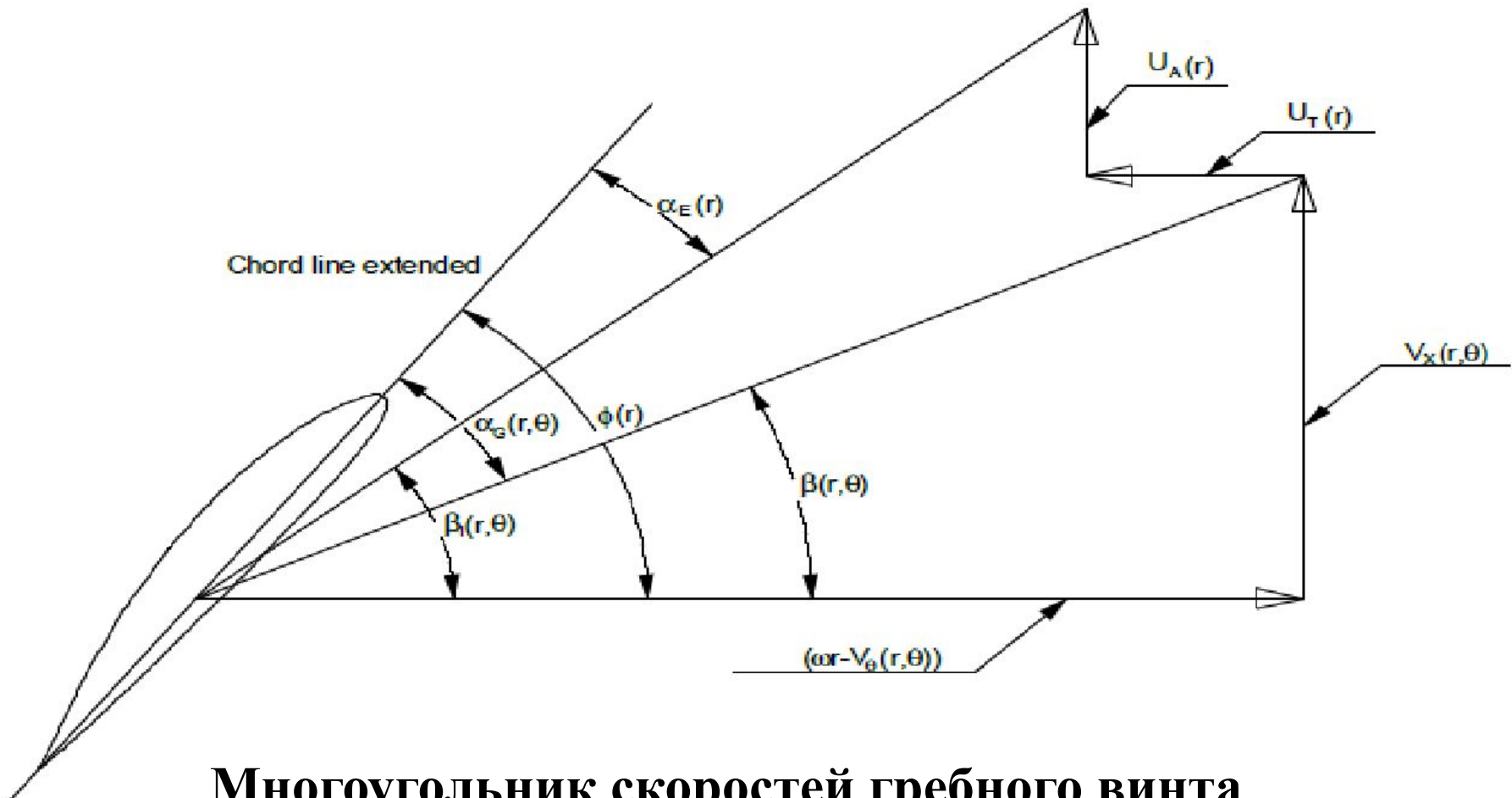


# Propeller series **СЕРИИ ГРЕБНЫХ ВИНТОВ**

**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 | $\simeq 120$                   | 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          | $\simeq 30$                    | 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<br>(mainly 4)   | 0.587 Principal<br>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                            |

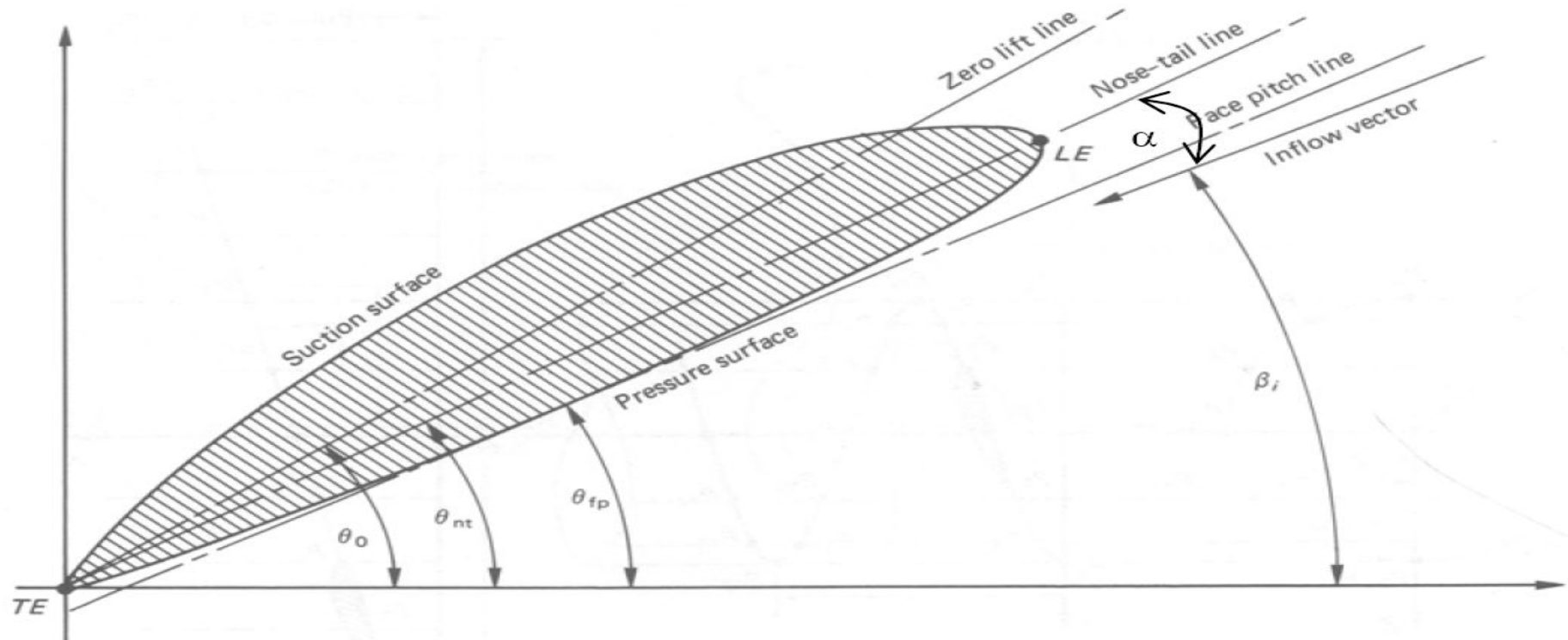
# Кинематика гребного винта



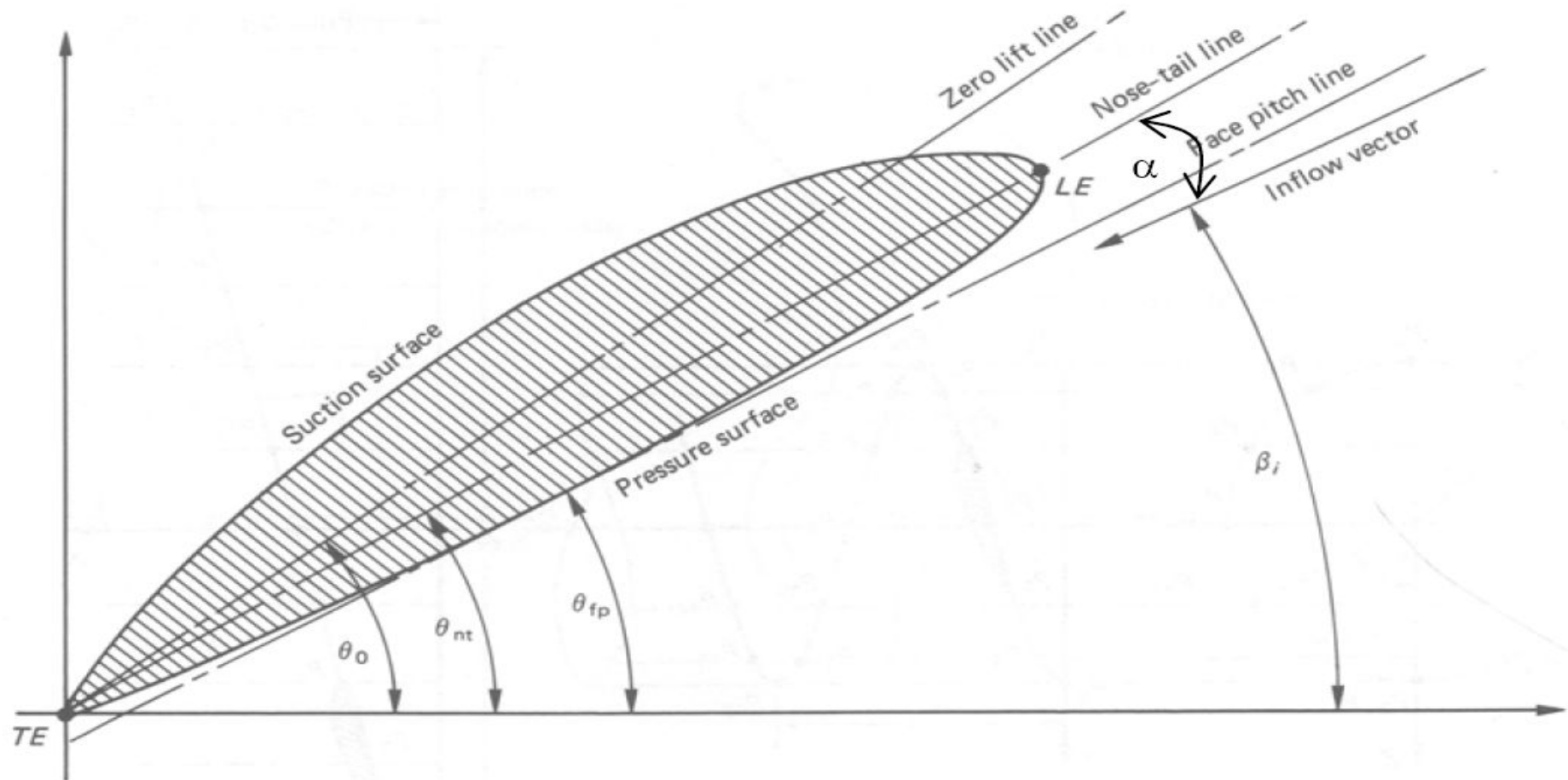
Многоугольник скоростей гребного винта

## • Понятия ШАГА и ШАГОВОГО УГЛА винта:

- $\theta_0$  is the effective pitch angle of the propeller
- $\theta_{nt}$  or  $\theta$  is the geometric pitch angle of the propeller
- $\beta_i$  is the hydrodynamic pitch angle
- $\alpha$  is the angle of attack of section

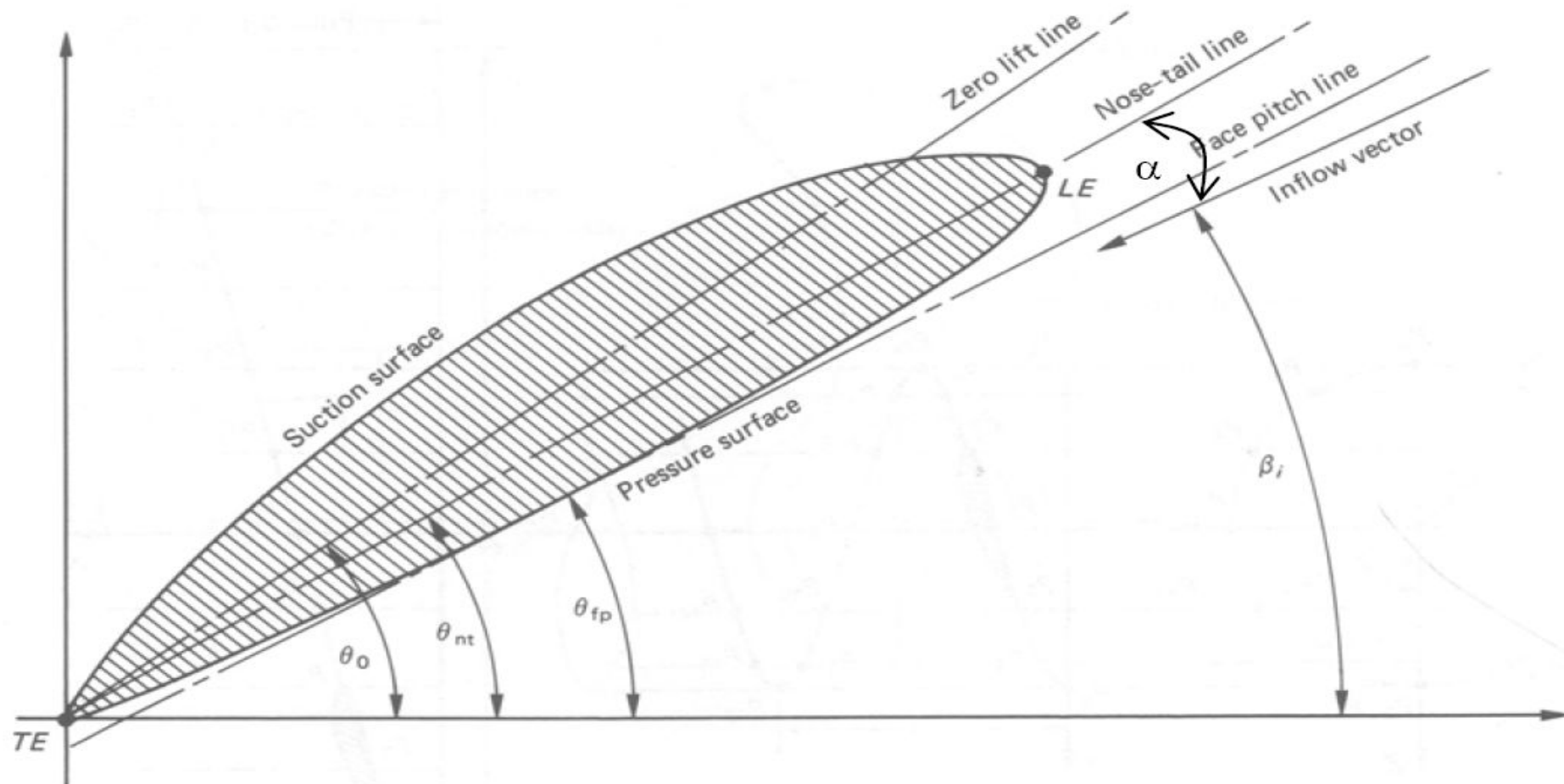


- **Nose-tail pitch: ГЕОМЕТРИЧЕСКИЙ ШАГ** The straight line connecting the extremities of the mean line or nose and tail of a propeller blade is called nose-tail pitch line The section angles of attack are defined to the nose-tail line.

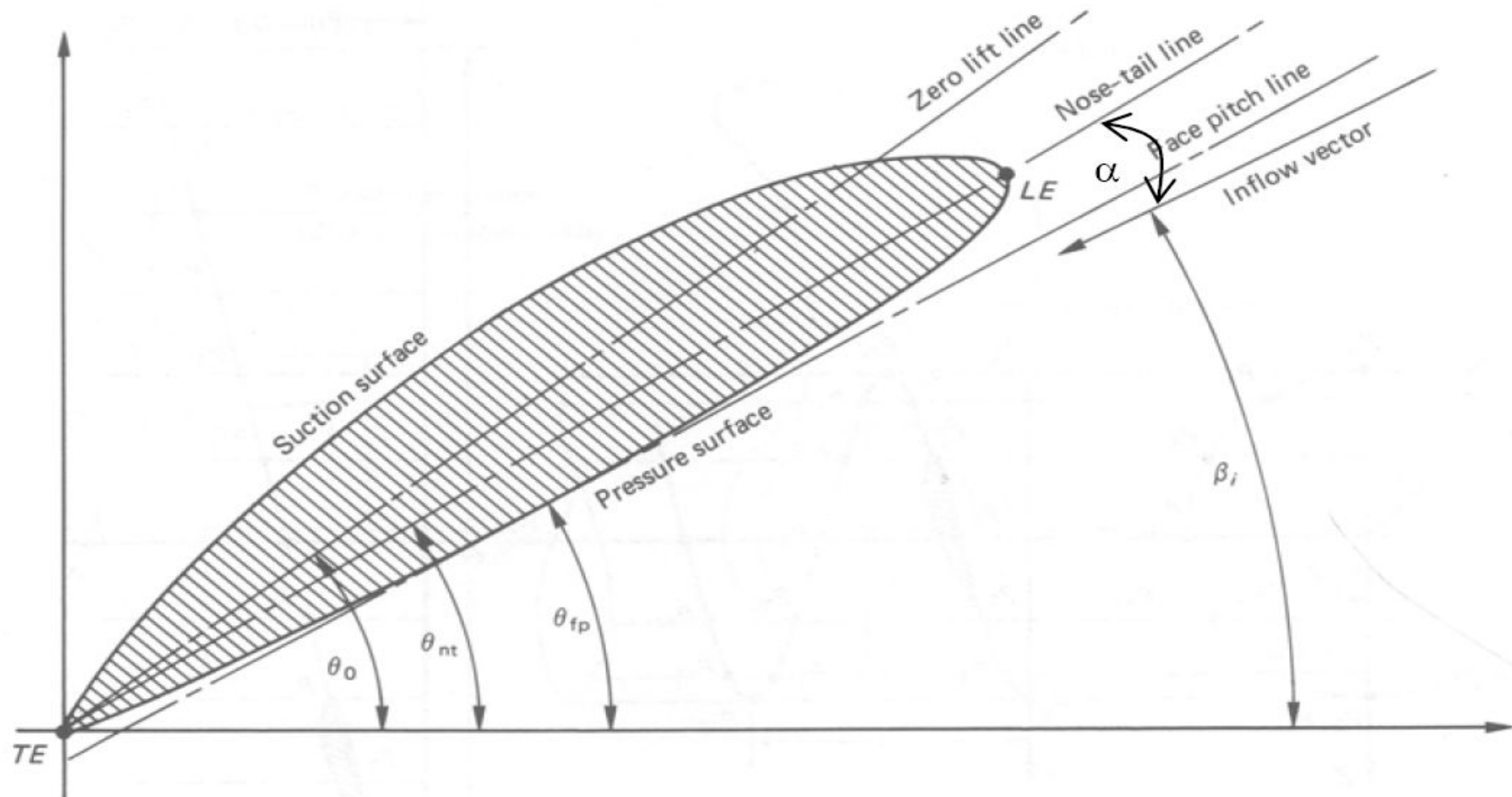




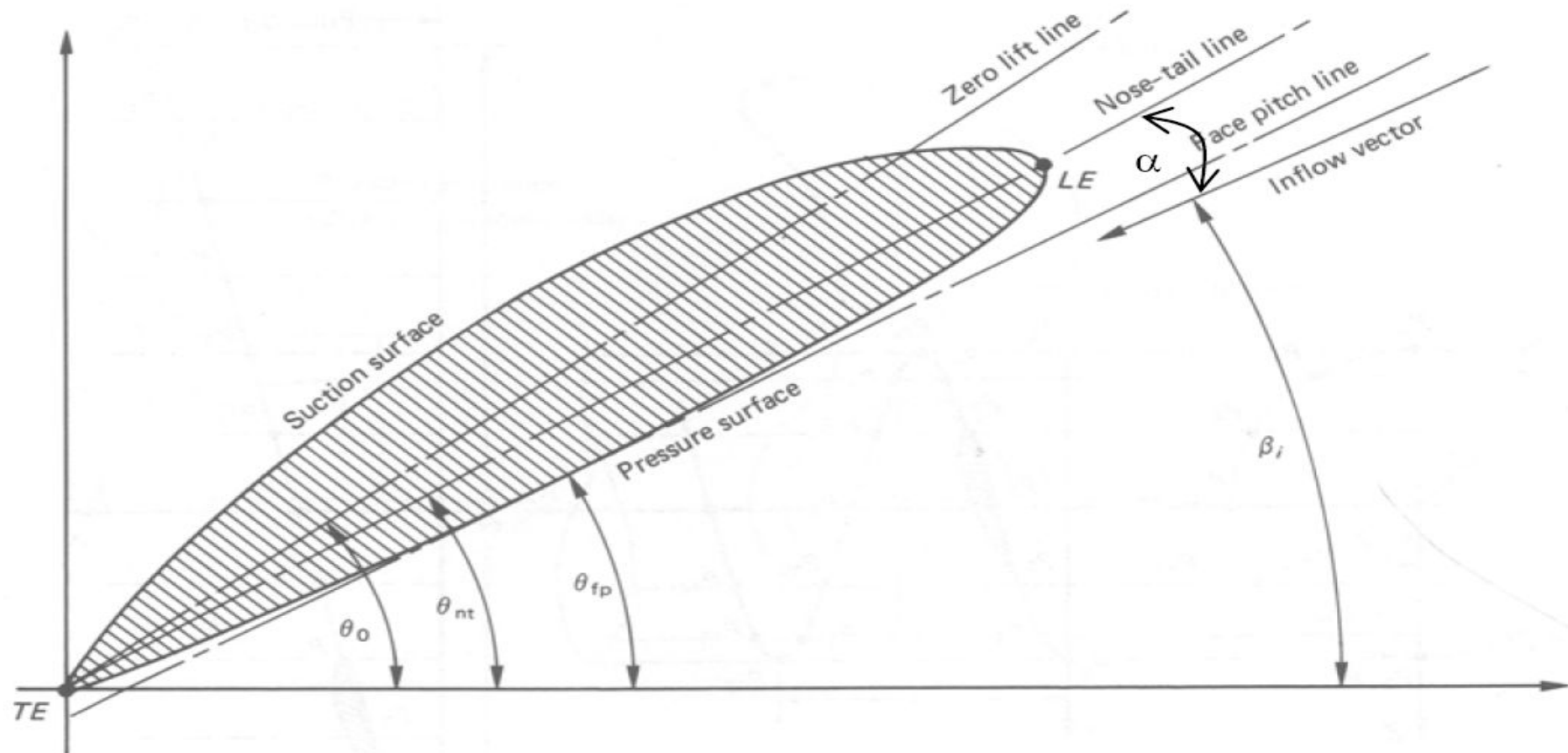
- Face pitch: **ШАГ НАГНЕТАЮЩЕЙ ПОВЕРХНОСТИ** The face pitch line is basically a tangent to section's pressure side surface and you can draw so many lines to the pressure side. Therefore its definition is not clear. It is rarely used but it can be seen in older drawings like Wageningen B series.



- 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.



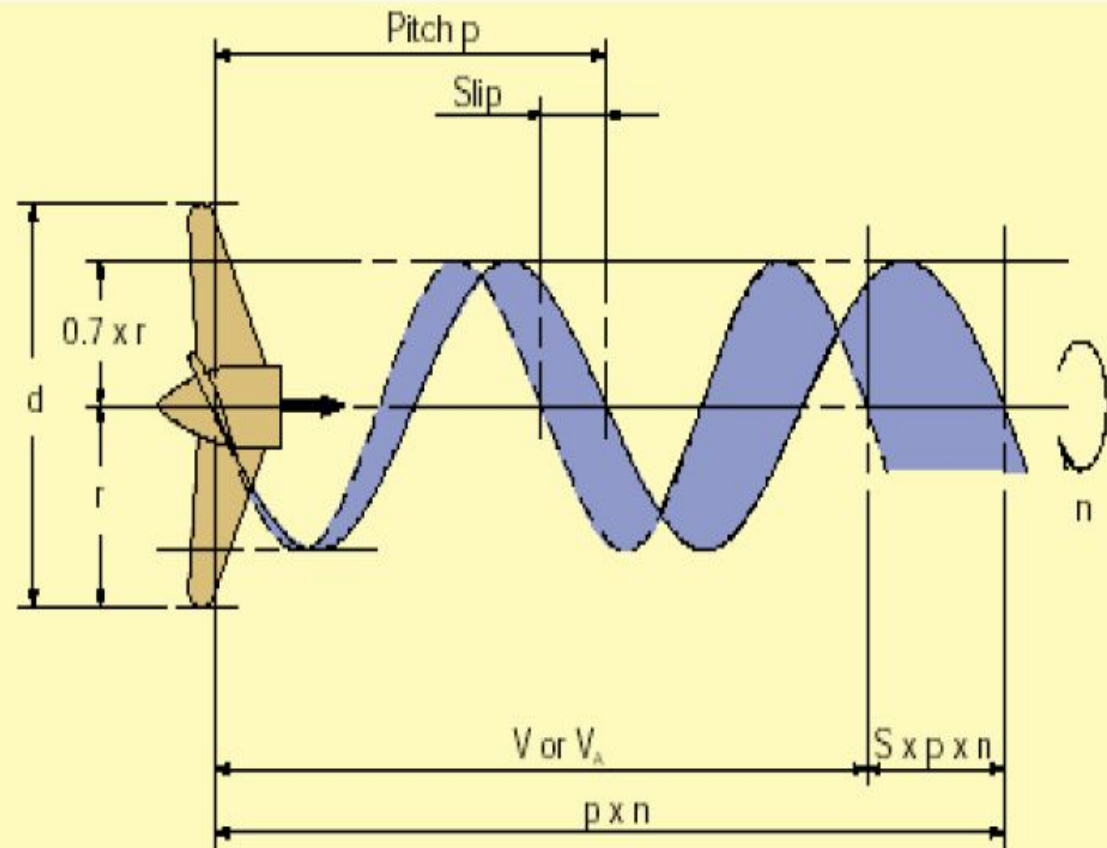
- Hydrodynamic pitch **ГИДРОДИНАМИЧЕСКИЙ ШАГ** : The hydrodynamic pitch angle ( $\beta_i$ ) is the pitch angle at which the incident flow encounters the blade section.
- Pitch values at different radii are called radial pitch distribution.



- Slip & Slip Ratio/ Скольжение и относительное скольжение

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

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



The apparent slip ratio :  $S_A = \frac{p \times n - V}{p \times n} = 1 - \frac{V}{p \times n}$

The real slip ratio :  $S_R = \frac{p \times n - V_A}{p \times n} = 1 - \frac{V_A}{p \times n}$



