

Fourth School Year

## WATER TURBINES

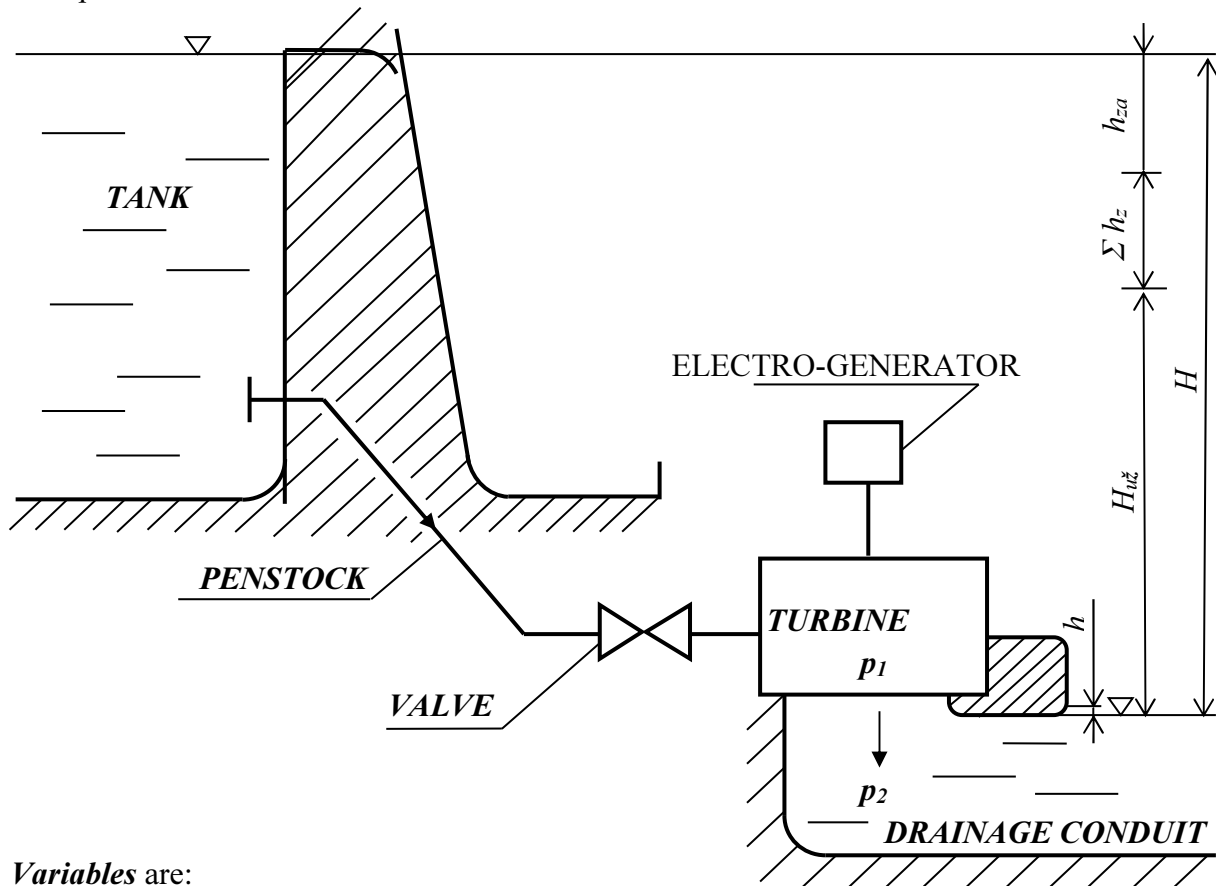
1. Water turbines are rotating **blade** machines. They use water power. Water changes its own potential energy into kinetic energy. Kinetic water energy is transferred by circulating turbine **blades** on a **runner**. The **runner** creates the rotating moment on the **shaft**. The **shaft** drives an electro-generator. Every turbine has distribution equipment and a **runner**.

An **impulse turbine** has the same pressure in front of the **runner** and behind it (as in a Pelton turbine).

A **reaction turbine** has greater pressure in front of the **runner** than behind it (as in Francis, Kaplan, Dériaz turbines).

### 2. A waterworks with a reaction turbine

Below you can see a picture of a **waterworks** with a **reaction turbine** including an explanation of its **variables**.



#### Variables are:

$H$  – geodesic head

$H_{už}$  – utilised head

$\Sigma h_z$  – penstock loss

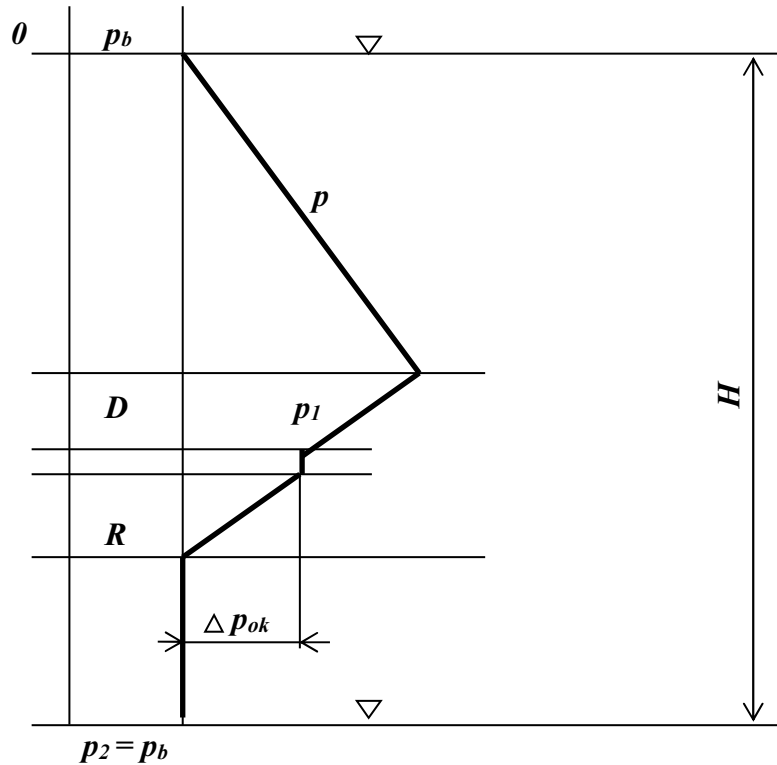
$h_{za}$  – height **loss** necessary for water **acceleration** in the **penstock**

$h$  – turbine placement (what is closest to the lower surface or even under the lower surface)

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### 3. Pressure flow in a reaction turbine

Below you can see a diagram of a pressure flow in a reaction turbine including its description.



Where is:

$D$  – distribution equipment

$R$  – **runner**

$p_1$  – inlet pressure

$p_b$  – barometric pressure

$p_2$  – outlet pressure from the **runner**

$p_2 < p_1$

$\Delta p_{ok}$  – **overpressure** in which the **runner** works

### 4. Effective output of the water turbine

This output we can calculate from the following formula:

$$P_e = Q_v \cdot \rho \cdot g \cdot H_{už} \cdot \eta [W]$$

Where the variables are:

$P_e$  – effective output

$Q_v$  – **volume flow**

$\rho$  – **density**

$g$  – gravitational **acceleration**

$H_{už}$  – **utilised head**

$\eta$  – **efficiency**

w - watt

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### VOCABULARY

<b>acceleration</b>	zrychlení
<b>blade</b>	lopatka turbíny
<b>density</b>	hustota
<b>drainage conduit</b>	odpadní kanál
<b>efficiency</b>	účinnost
<b>geodesic head</b>	geodetický spád
<b>impulse turbine</b>	rovnotlaká turbína
<b>loss</b>	ztráta
<b>overpressure</b>	přetlak
<b>penstock</b>	přivaděč
<b>reaction turbine</b>	přetlaková turbína
<b>runner</b>	oběžné kolo
<b>shaft</b>	hřídel
<b>tank</b>	nádrž
<b>utilised head</b>	využitý spád
<b>valve</b>	ventil
<b>variable</b>	proměnná veličina
<b>volume flow</b>	objemový průtok
<b>waterworks</b>	vodní dílo

### COMPREHENSION QUESTIONS

1. What is a water turbine?
2. What does a water turbine use?
3. What is a runner?
4. What is the difference between an impulse and a reaction turbine?

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**EXERCISES**

1. **Hidden message** - 15 words were placed into the puzzle.

R V E E R A C T P N I O N S T  
U R A B F E I E N O E U S B V  
T J A R E F N C N I D O G A S  
X X C D I S I N R T L W U T F  
G Z T X T A N C U A K Z W V Y  
Y O M O G S B R I R N J R H H  
H I C K Y U V L P E Z F C S M  
R K D O D R K E E L N Z M R M  
O C J K T F L X V E U C I E F  
T F A H S A L Q A C T B Y F E  
G Z Q M C C N P X C P F A S V  
Y T I S N E D K M A R P Z N L  
O V E R P R E S S U R E H A A  
O U T L E T H E I G H T B R V  
F G R V N S Z X M L M P E T K

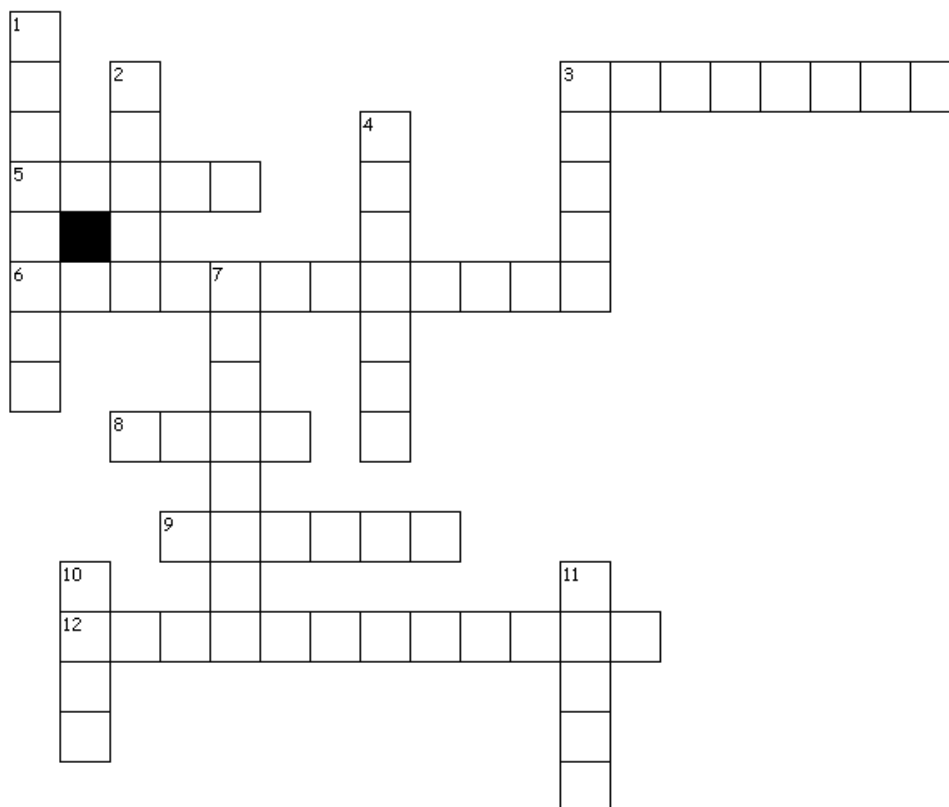
ACCELERATION	DENSITY	EFFICIENCY
HEIGHT	LOSS	OUTLET
OVERPRESSURE	PENSTOCK	RUNNER
SHAFT	SURFACE	TANK
TRANSFER	VALVE	VARIABLE

**Hidden message**

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2. Criss Cross Puzzle - 13 words were placed into the puzzle.



**Across**

- 3. proměnná veličina
- 5. hřidel
- 6. přetlak
- 8. ztráta
- 9. oběžné kolo
- 12. zrychlení

**Down**

- 1. přiváděč
- 2. lopatka
- 3. ventil
- 4. hustota
- 7. tlak
- 10. nádrž
- 11. spodní

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**EXERCISES – KEY FOR TEACHERS**

**1. Hidden message – REACTION TURBINE**

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R V E E R A C T P N I O N S T
U R A B F E I E N O E + S + +
+ + + R + F N + + I + O + + +
+ + + + I S I N + T L + + + +
+ + + + T A + C U A + + + + +
+ + + O + S B + I R + + + + +
+ + C + + U + L + E + + + + +
+ K + + + R + + E L N + + R +
+ + + + T F + + + E + C + E +
T F A H S A + + + C + + Y F E
+ + + + + C N + + C + + + S V
Y T I S N E D K + A + + + N L
O V E R P R E S S U R E + A A
O U T L E T H E I G H T + R V
+ + + + + + + + + + + + T +
    
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(Over,Down,Direction)  
ACCELERATION(10,12,N)  
DENSITY(7,12,W)  
EFFICIENCY(4,1,SE)  
HEIGHT(7,14,E)  
LOSS(11,4,NE)  
OUTLET(1,14,E)  
OVERPRESSURE(1,13,E)  
PENSTOCK(9,1,SW)  
RUNNER(10,6,NW)  
SHAFT(5,10,W)  
SURFACE(6,6,S)  
TANK(5,9,SE)  
TRANSFER(14,15,N)  
VALVE(15,14,N)  
VARIABLE(2,1,SE)

**2. Criss Cross Puzzle**

<b>blade</b>	lopatka
<b>variable</b>	proměnná veličina
<b>valve</b>	ventil
<b>loss</b>	ztráta
<b>tank</b>	nádrž
<b>penstock</b>	přivaděč
<b>runner</b>	oběžné kolo
<b>density</b>	hustota
<b>shaft</b>	hřídel
<b>acceleration</b>	zrychlení
<b>lower</b>	spodní
<b>overpressure</b>	přetlak
<b>pressure</b>	tlak