16th Seminar of the ISTC Scientific Advisory Committee
"ENERGY SECURITY, HOW TO FURTHER THE TECHNOLOGY"

OPTIMIZATION METHODS OF THE ENERGY BALANCE IN THE LEADING COUNTRIES ON THE BASIS OF USE OF THE HIGHLY EFFECTIVE WIND POWER STATIIONS

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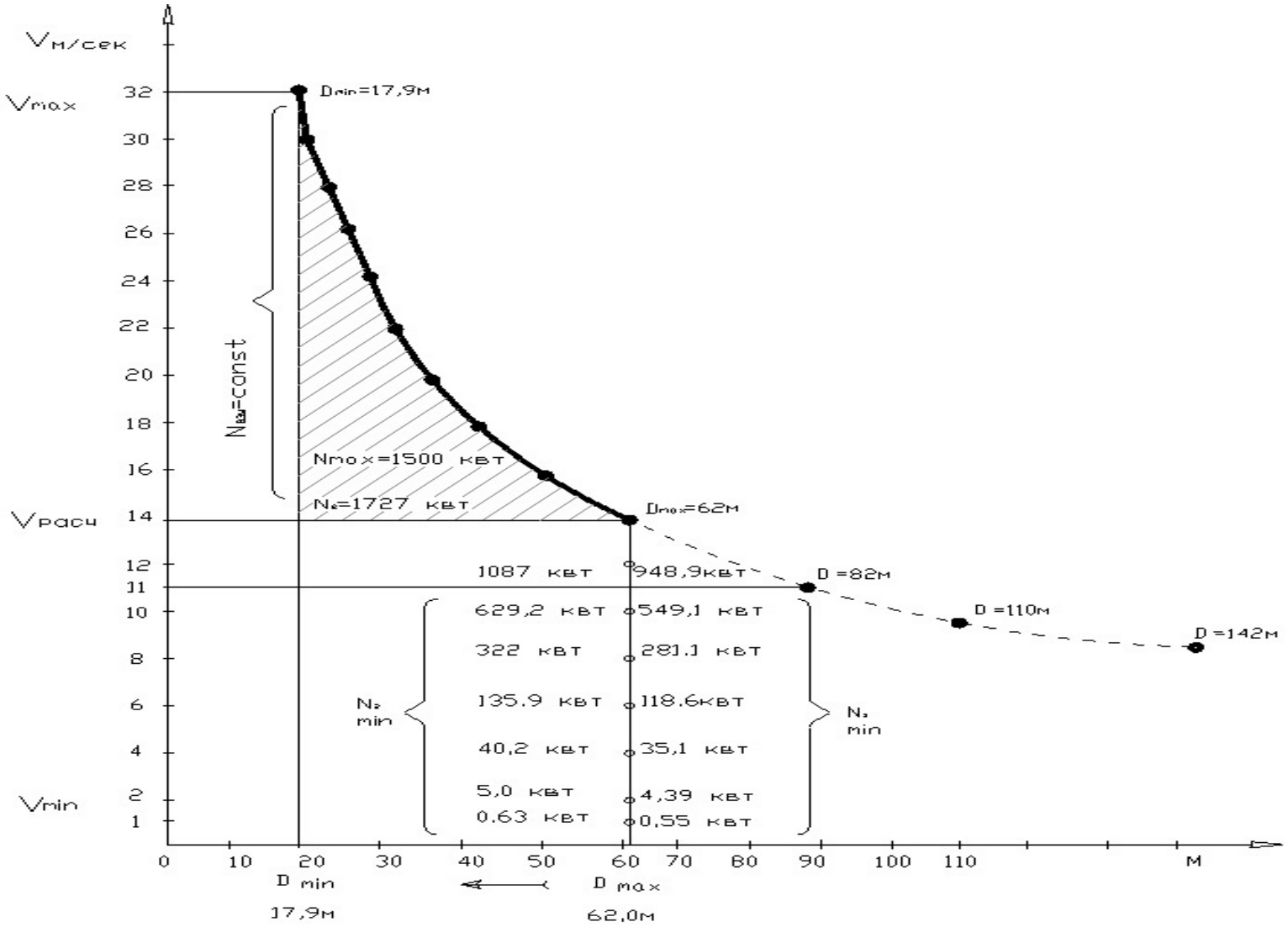
Almaty, Republic of Kazakhstan



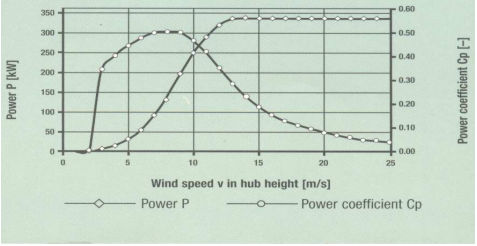
Necessary combination of the rotor diameter and wind speed for acquisition of the planned power of wind station

E33

Calculated power curve

Wind (m/s)	Power P (kW)	Power coefficient Cp (–)
1	0.0	0.00
2	0.0	0.00
3	5.0	0.35
4	13.7	0.40
5	30.0	0.45
6	55.0	0.47
7	92.0	0.50
8	138.0	0.50
9	196.0	0,50
10	250.0	0.47
11	292.8	0.41
12	320.0	0.35
13	335.0	0.28
14	335.0	0.23
15	335.0	0.18
16	335.0	0.15
17	335.0	0.13
18	335.0	0.11
19	335.0	0.09
20	335.0	0.08
21	335.0	0.07
22	335.0	0.06
23	335.0	0.05
24	335.0	0.05
25	335.0	0.04

ρ = 1,225 kg/m³

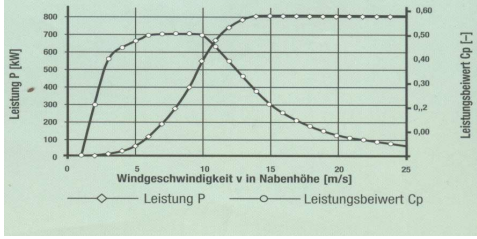


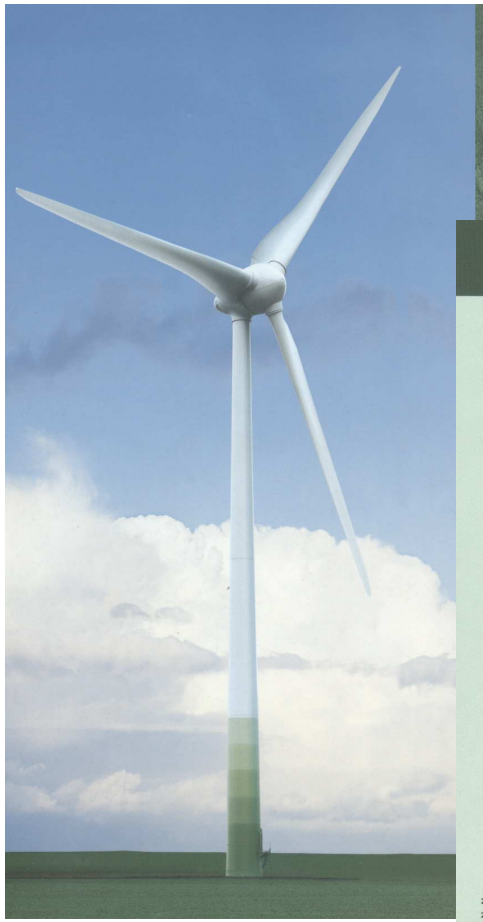
E48

berechnete Leistungskennlinie

Wind (m/s)	Leistung P (kW)	Leistungsbeiwert Cp (-)
1	0,0	0,00
2	2,0	0,23
3	12,0	0,40
4	32,0	0,45
5	66,0	0,48
6	120,0	0,50
7	191,0	0,50
8	284,0	0,50
9	405,0	0,50
10	555,0	0,50
11	671,0	0,45
12	750,0	0,39
13	790,0	0,32
14	810,0	0,27
15	810,0	0,22
16	810,0	0,18
17	810,0	0,15
18	810,0	0,13
19	810,0	0,11
20	810,0	0,09
21	810,0	0,08
22	810,0	0,07
23	810,0	0,06
24	810,0	0,05
25	810,0	0,05

ρ = 1,225 kg/m³



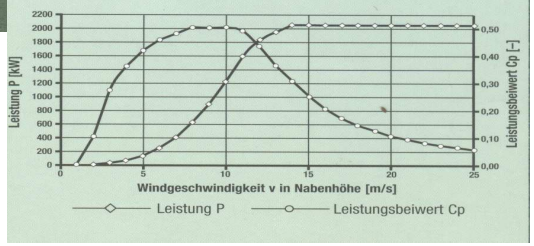


E70

berechnete Leistungskennlinie

Wind (m/s)	Leistung P (kW)	Leistungsbeiwert Cp (-)
1	0,0	0,00
2	2,0	0,10
3	18,0	0,27
4	56,0	0,36
5	127,0	0,42
6	240,0	0,46
7	400,0	0,48
8	626,0	0,50
9	892,0	0,50
10	1223,0	0,50
11	1590,0	0,49
12	1830,0	0,44
13	1950,0	0,37
14	2050,0	0,31
15	2050,0	0,25
16	2050,0	0,21
17	2050,0	0,17
18	2050,0	0,14
19	2050,0	0,12
20	2050,0	0,11
21	2050,0	0,09
22	2050,0	0,08
23	2050,0	0,07
24	2050,0	0,06
25	2050,0	0,05

$\rho = 1{,}225\ kg/m^3$

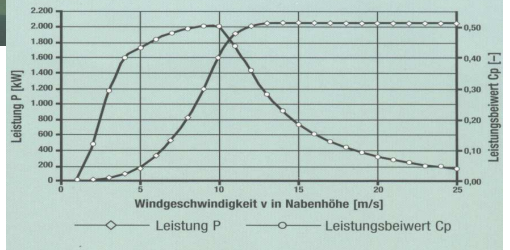


E82

berechnete Leistungskennlinie

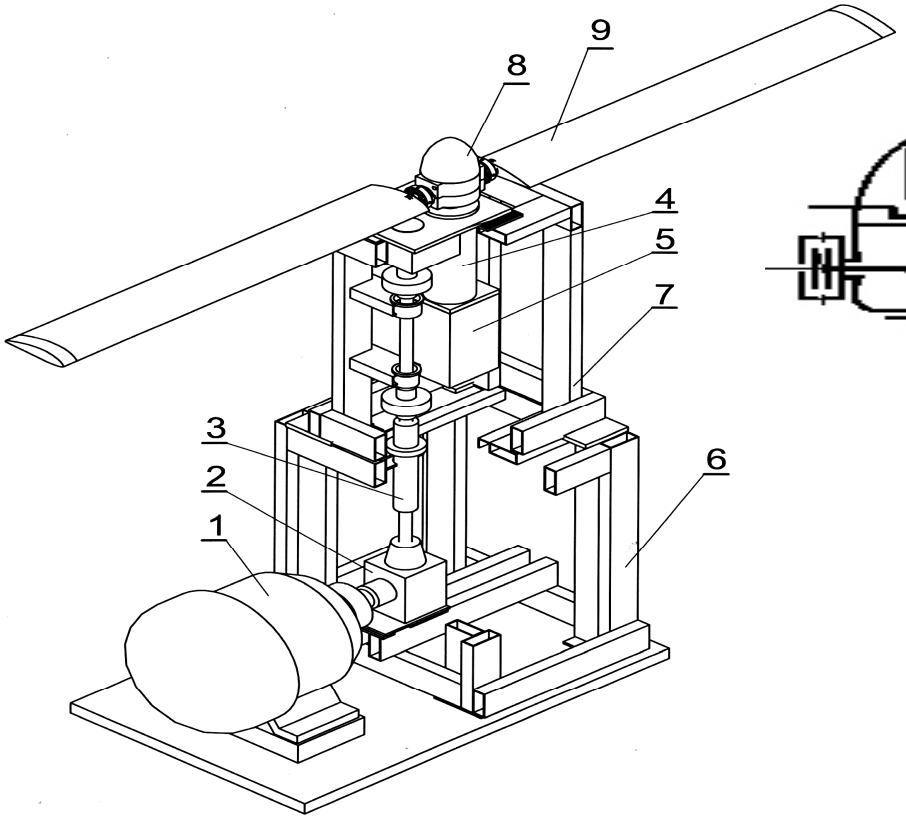
Wind (m/s)	Leistung P (kW)	Leistungsbeiwert Cp (-)
1	0,0	0,00
2	3,0	0,12
3	25,0	0,29
4	82,0	0,40
5	174,0	0,43
6	321,0	0,46
7	532,0	0,48
8	815,0	0,49
9	1180,0	0,50
10	1612,0	0,50
11	1890,0	0,44
12	2000,0	0,36
13	2050,0	0,29
14	2050,0	0,23
15	2050,0	0,19
16	2050,0	0,15
17	2050,0	0,13
18	2050,0	0,11
19	2050,0	0,09
20	2050,0	0,08
21	2050,0	0,07
22	2050,0	0,06
23	2050,0	0,05
24	2050,0	0,05
25	2050,0	0,04

$\rho = 1{,}225\ kg/m^3$

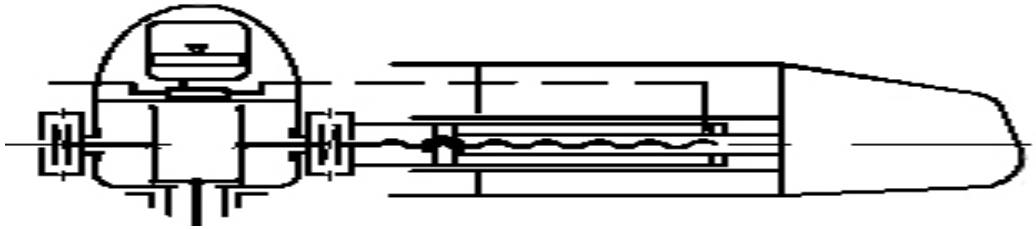


Power plant E-33, properties of its modernization and modernization efficiency

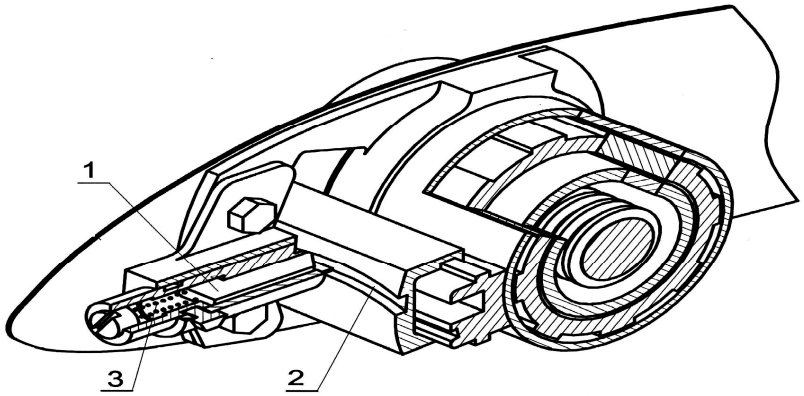
Type	E-33		E-33 Modern		Effect	E-48		E-33/48		Effect	
V m/s	Dm	PkW	Dm	PkW	kW	Dm	PkW	Dm	PkW	kW	+%
1	33	0.0	33	0.0	-	48	0.0	48	0.0	0.0	0
2	33	0.0	33	0.0	-	48	2.0	48	2.0	2.0	0
3	33	5.0	33	5.0	-	48	12.0	48	12.0	7.0	240
4	33	13.7	33	13.7	-	48	32.0	48	32.0	18.3	233
5	33	30.0	33	30.0	-	48	66.0	48	66.0	36.0	120
6	33	55.0	33	55.0	-	48	120.0	48	120.0	65.0	118
7	33	92.0	33	92.0	-	48	191.0	48	191.0	99	207
8	33	138.0	33	138.0	-	48	284.0	48	284.0	146	179
9	33	196.0	33	196.0	-	48	405	44	335.0	139	171
10	33	250..0	33	250..0	-	48	555	42	335.0	85	134
11	33	292.0	33	292.0	-	48	671	40	335.0	43	114
12	33	320.0	33	320.0	-	48	750	38	335.0	15	104
13	33	335.0	33	335.0	-	-	-	33	335.0	-	-
14	33	335.0	33	335.0	-	-	-	33	335.0	-	-
15	33	335.0	33	335.0	-	-	-	33	335.0	-	-
16	33	335.0	33	335.0	-	-	-	33	335.0	-	-
17	33	335.0	33	335.0	-	-	-	33	335.0	-	-
18	33	335.0	33	335.0	-	-	-	33	335.0	-	-
19	33	335.0	33	335.0	-	-	-	33	335.0	-	-
20	33	335.0	33	335.0	-	-	-	33	335.0	-	-
21	33	335.0	33	335.0	-	-	-	33	335.0	-	-
22	33	335.0	33	335.0	-	-	-	33	335.0	-	-
23	33	335.0	33	335.0	-	-	-	33	335.0	-	-
24	33	335.0	33	335.0	-	-	-	33	335.0	-	-
25	33	335.0	33	335.0	-	-	-	33	335.0	-	-
26	-	-	31,1	335.0	335.0	-	-	31,1	335.0	335.0	100
27	-	-	29,4	335.0	335.0	-	-	29,4	335.0	335.0	100
28	-	-	27,8	335.0	335.0	-	-	27,8	335.0	335.0	100
29	-	-	26,4	335.0	335.0	-	-	26,4	335.0	335.0	100



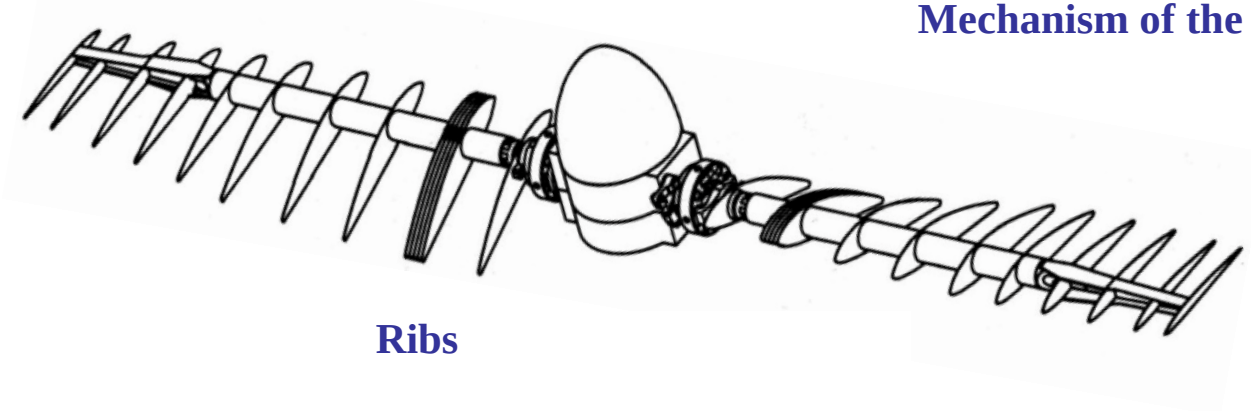
Stand for dynamic tests



Mechanism of the diameter change



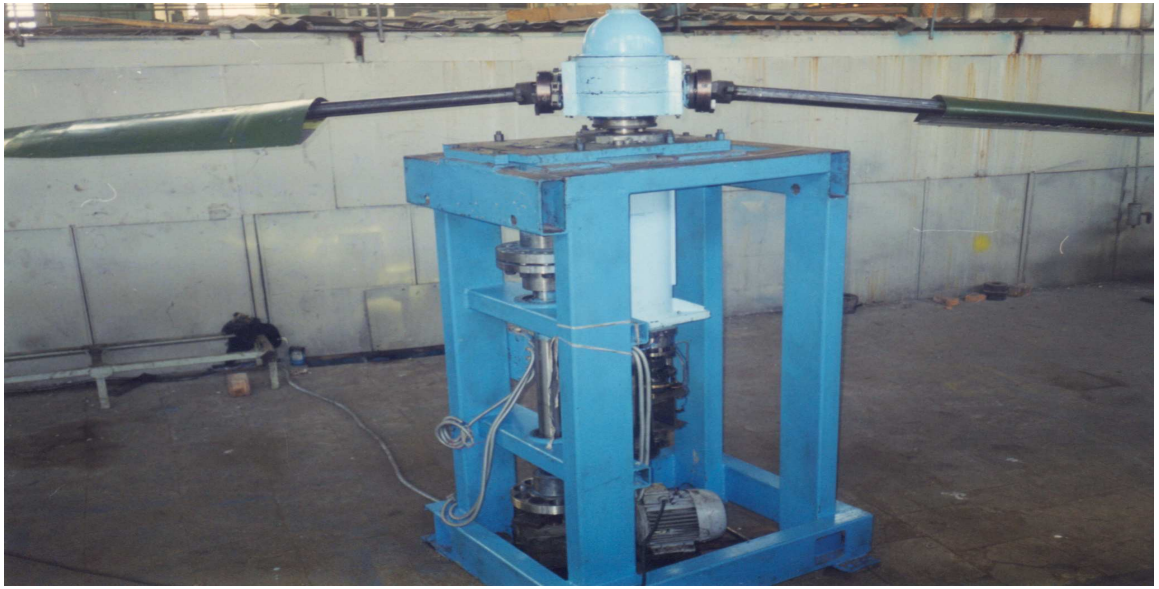
Mechanism of the twist change



Ribs

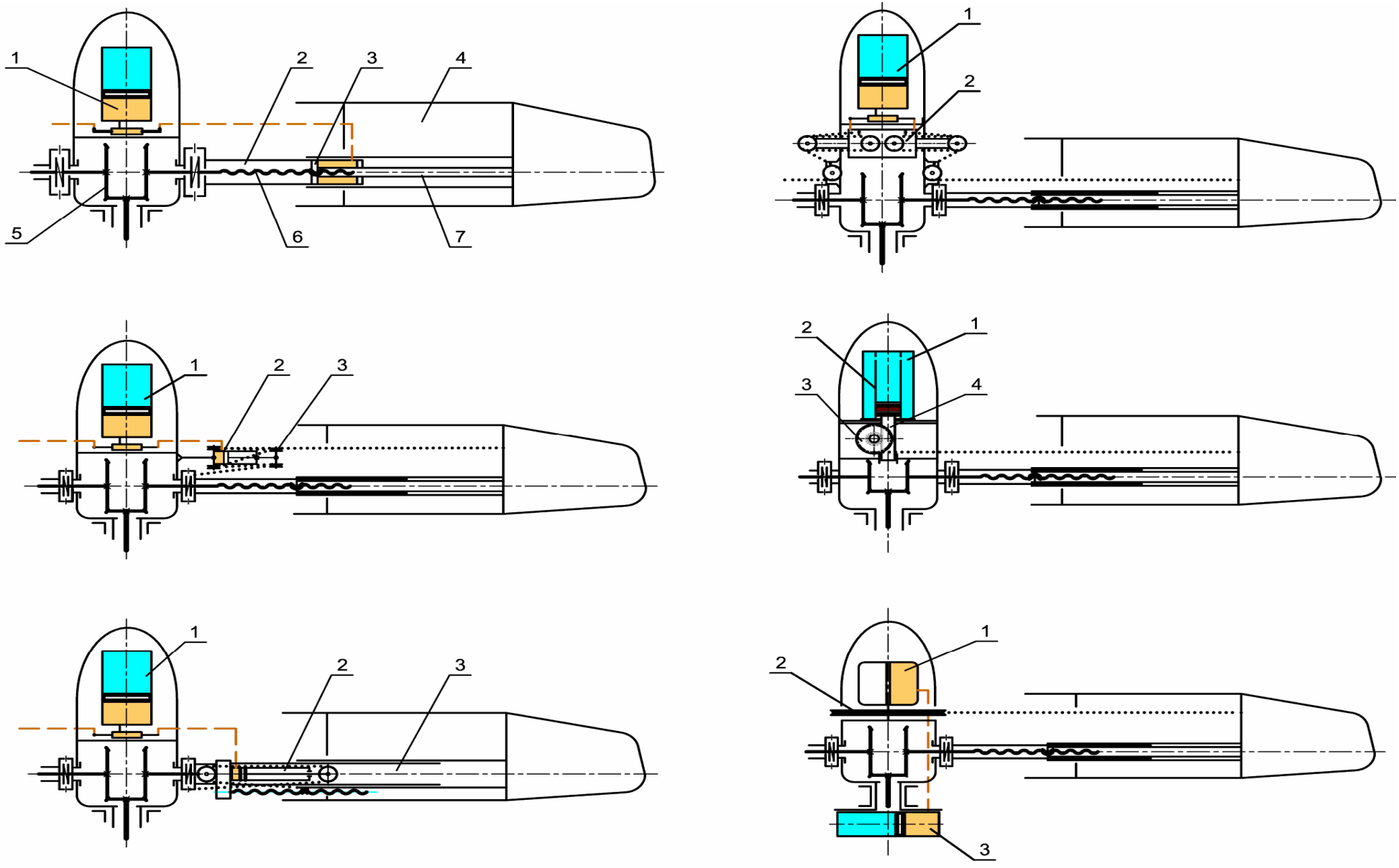
A

B

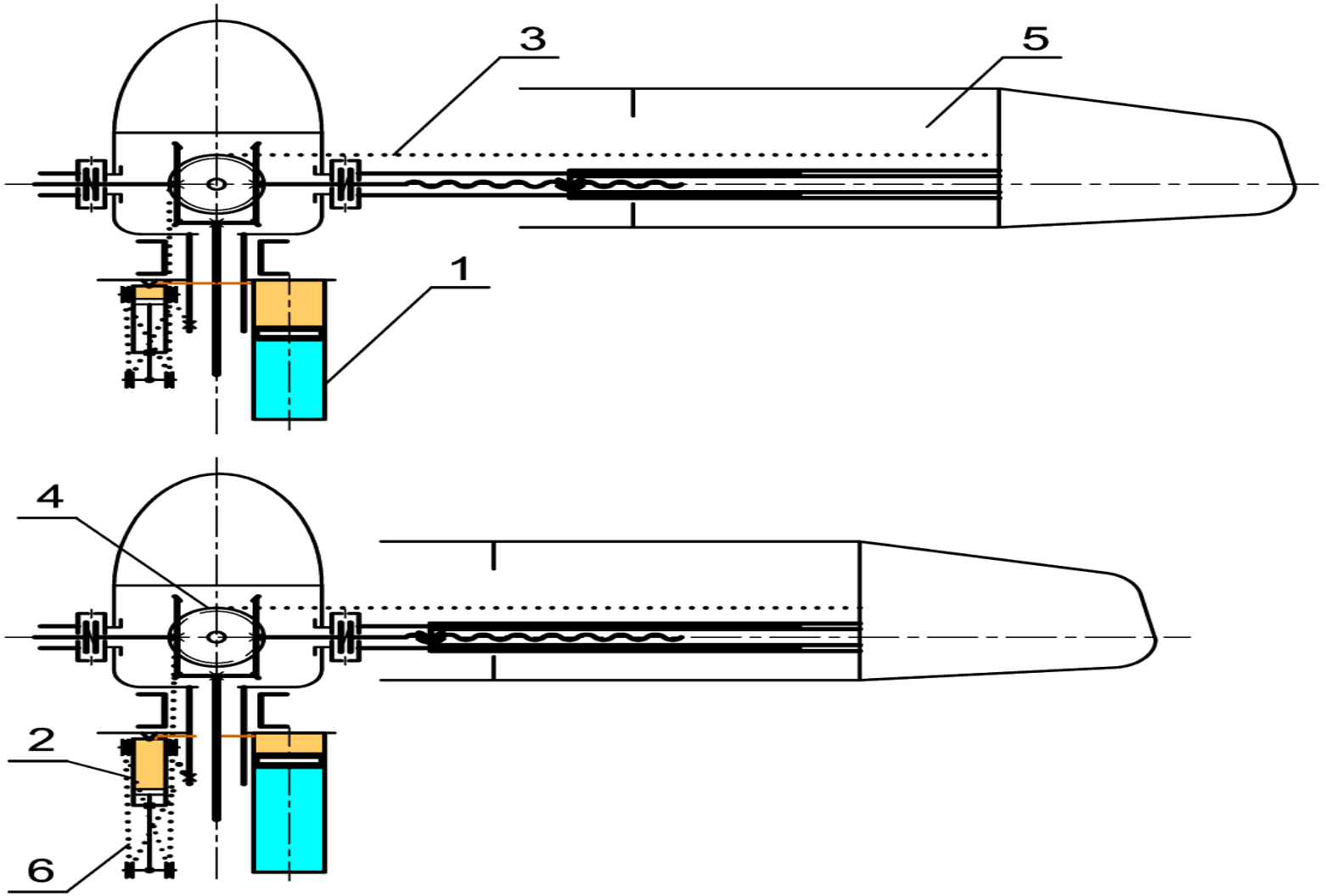


A - Rotor with the minimum diameter, B - Rotor with the maximum diameter.

Casing of the blade



Design versions of compensation of centrifugal forces



Schematic arrangement of the VGR with position of the hydro-pneumo-accumulator and hydro-cylinder below the rotor hub.
1 - Hydro-pneumatic accumulator, 2 - Hydro-cylinder, 3-Rope, 4-Roller, 5-Blade, 6-Pulley block.

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Date
30.12.09

Reference	Application No./Patent No.
	08737551.5 - 2422 PCT/IB200800104
Applicant/Proprietor	
Georgian Technical University (GTU)	

Notification of the data mentioned in Rule 19(3) EPC

In the above-identified patent application you are designated as inventor/co-inventor.
Pursuant to Rule 19(3) EPC the following data are notified herewith:

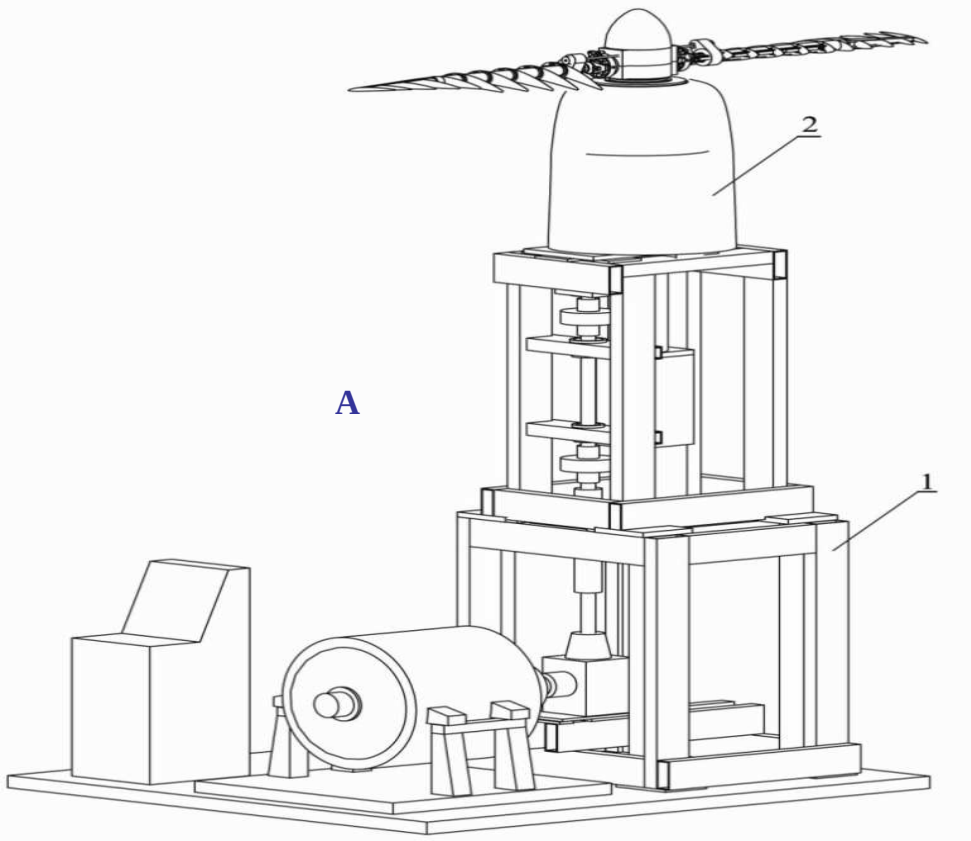
DATE OF FILING	: 28.04.08
PRIORITY	: GE/24.05.07/ GEA 1009407
TITLE	: VARIABLE-DIAMETER ROTOR WITH CENTRIFUGAL FORCES COMPENSATION MECHANISM
DESIGNATED STATES	: AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MT NL NO PL PT RO SE SI SK TR

Receiving Section

Europäisches Patentamt • European Patent Office • Office européen des brevets

EPO Form 1204 12.07

European Patent



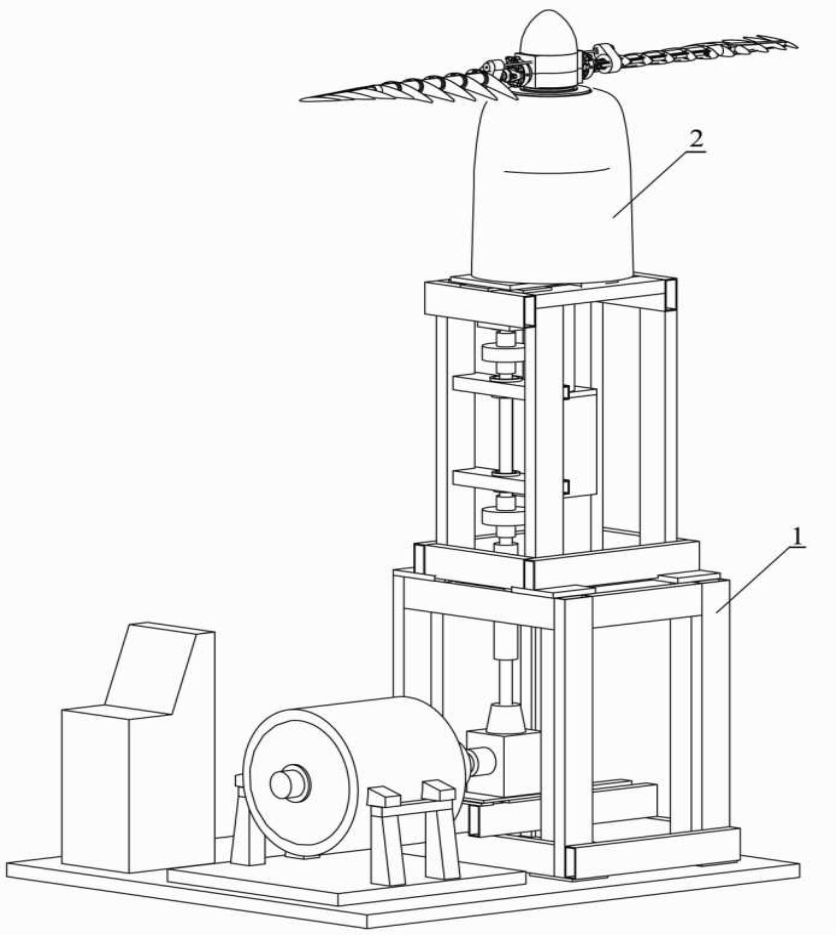
A

B

Project G-916

A - Diagram of the stand for dynamic tests of the VGR,

B - Mechanism of compensation of centrifugal forces.



Schematic arrangement of the stand for dynamic tests of the VGR

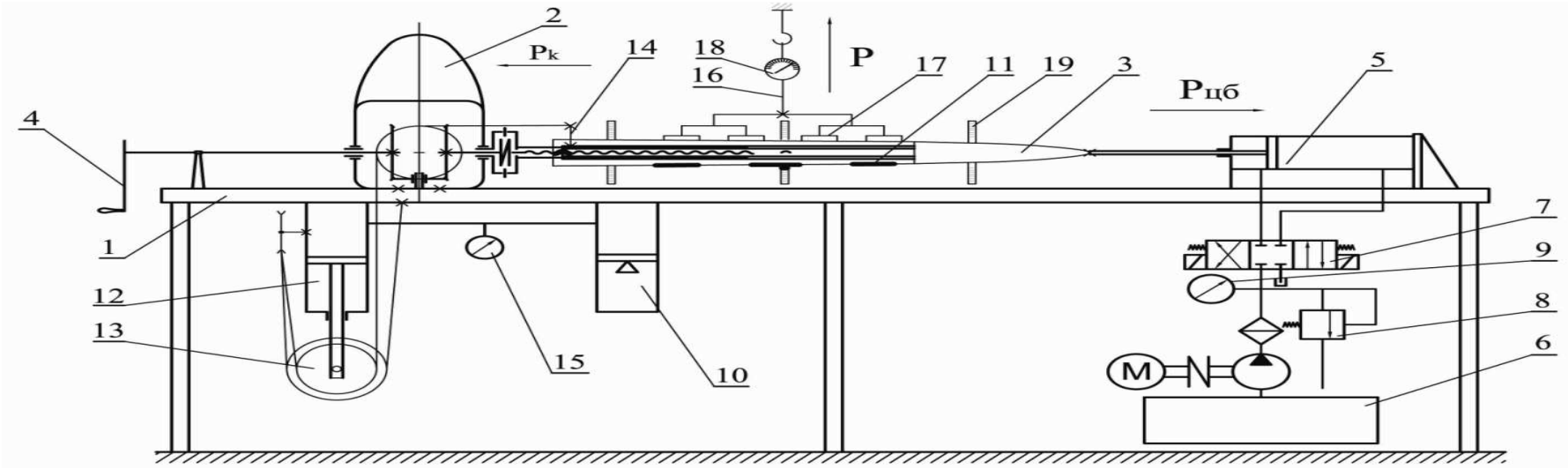
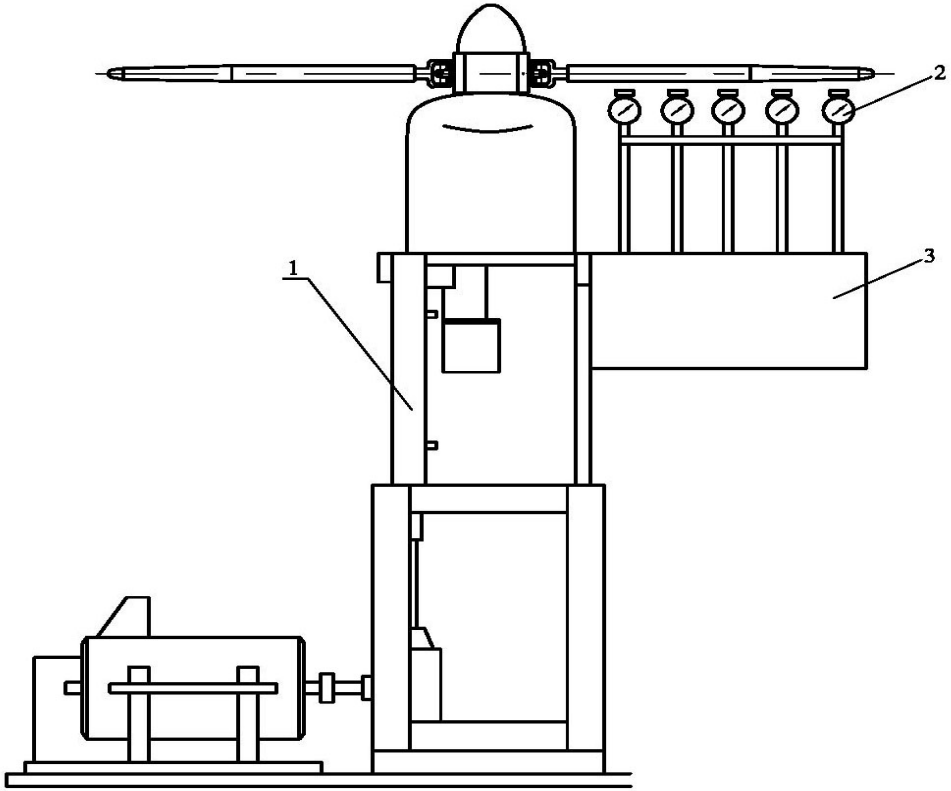


Diagram of the stand for static tests of the VGR

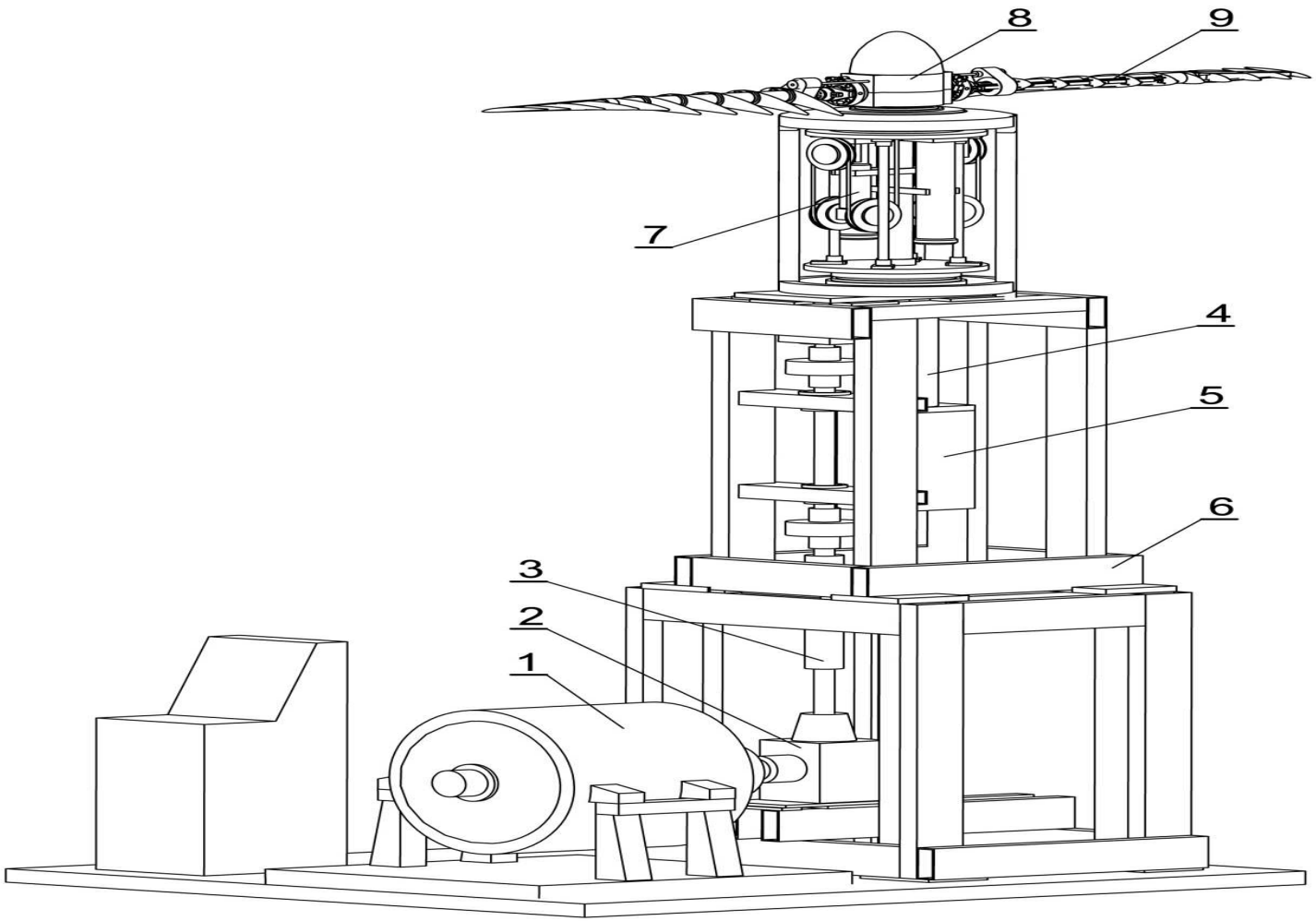
1–frame, 2–hub, 3-blade, 4–handle, 5–hydro-cylinder, 6– hydro-station, 7–hydro-distributor, 8–reverse valve, 9- mano-meter, 10–hydro-accumulator, 11–spar, 12–hydro-cylinder, 13–pulley-block, 14–corbel, 15-manometer, 16-rod, 17-lever system, 18-dynamometer, 19-ruler

Stand for static tests



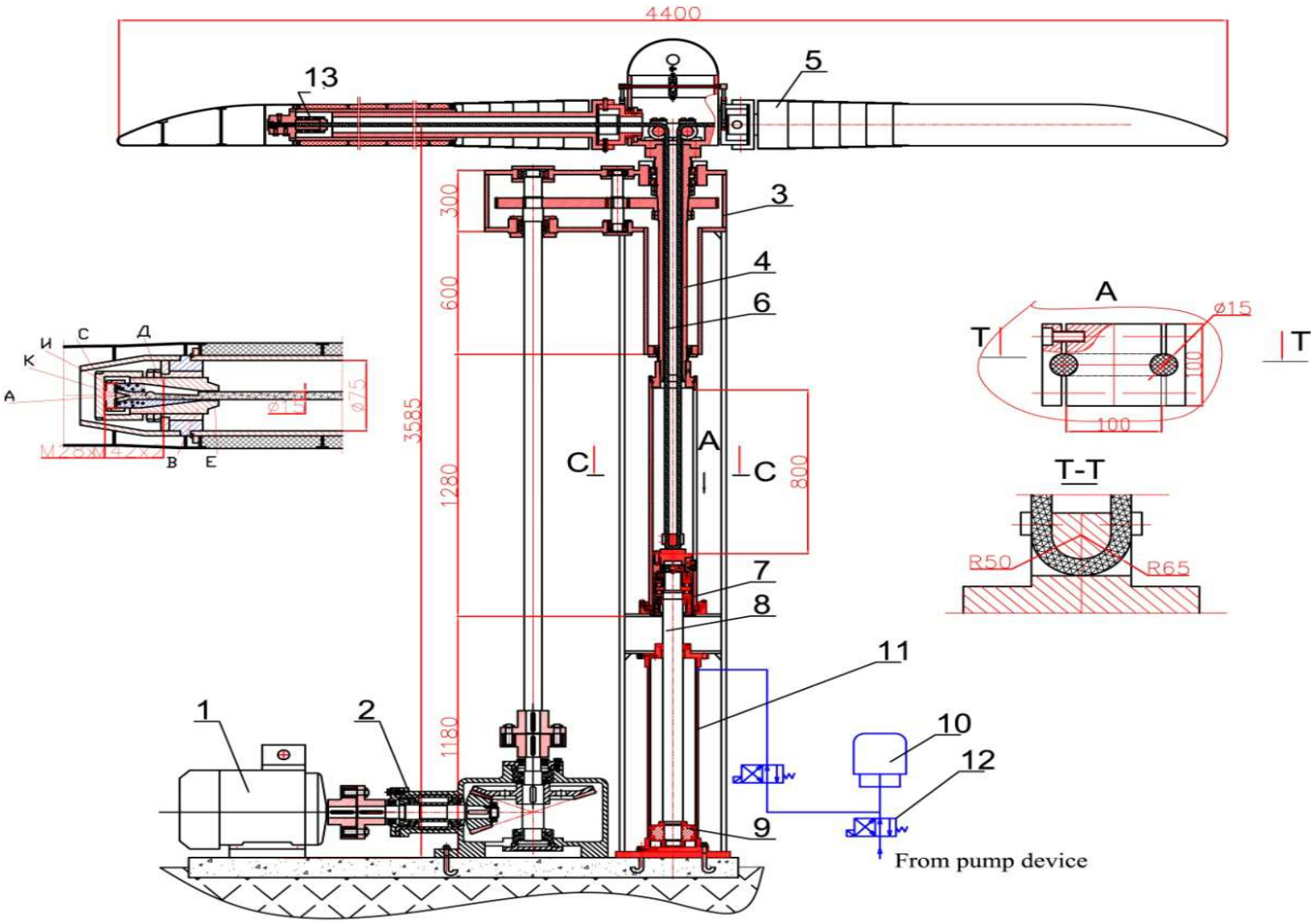
Revolving-vane analyzer ACO-3

Diagram of the device for measure of the rotor thrust on the stand by measuring speeds by means of anemometers.
1-VGR stand, 2–anemometers, 3–frame for setting anemometers

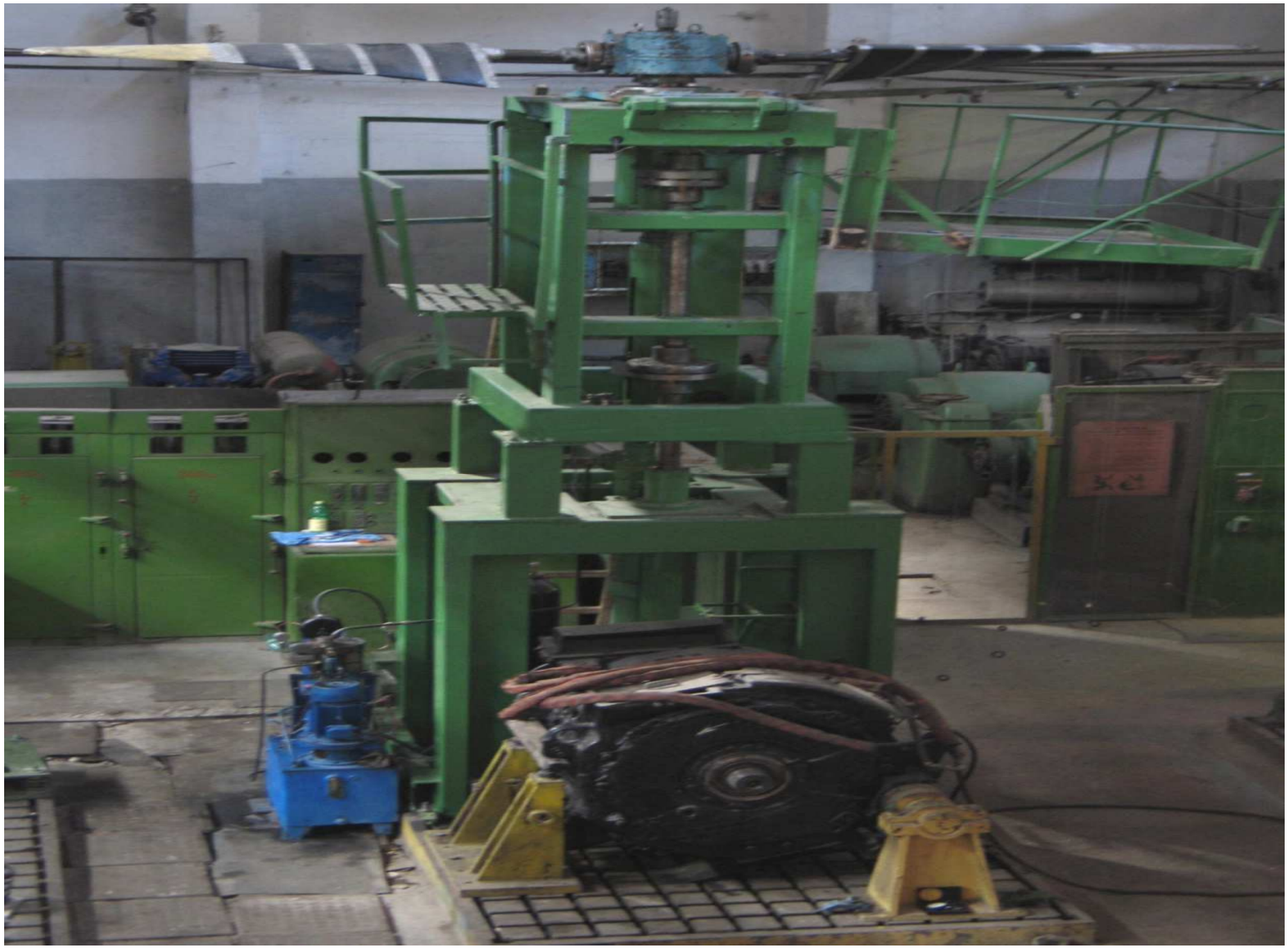


Stand for tests of the variable geometry rotor:

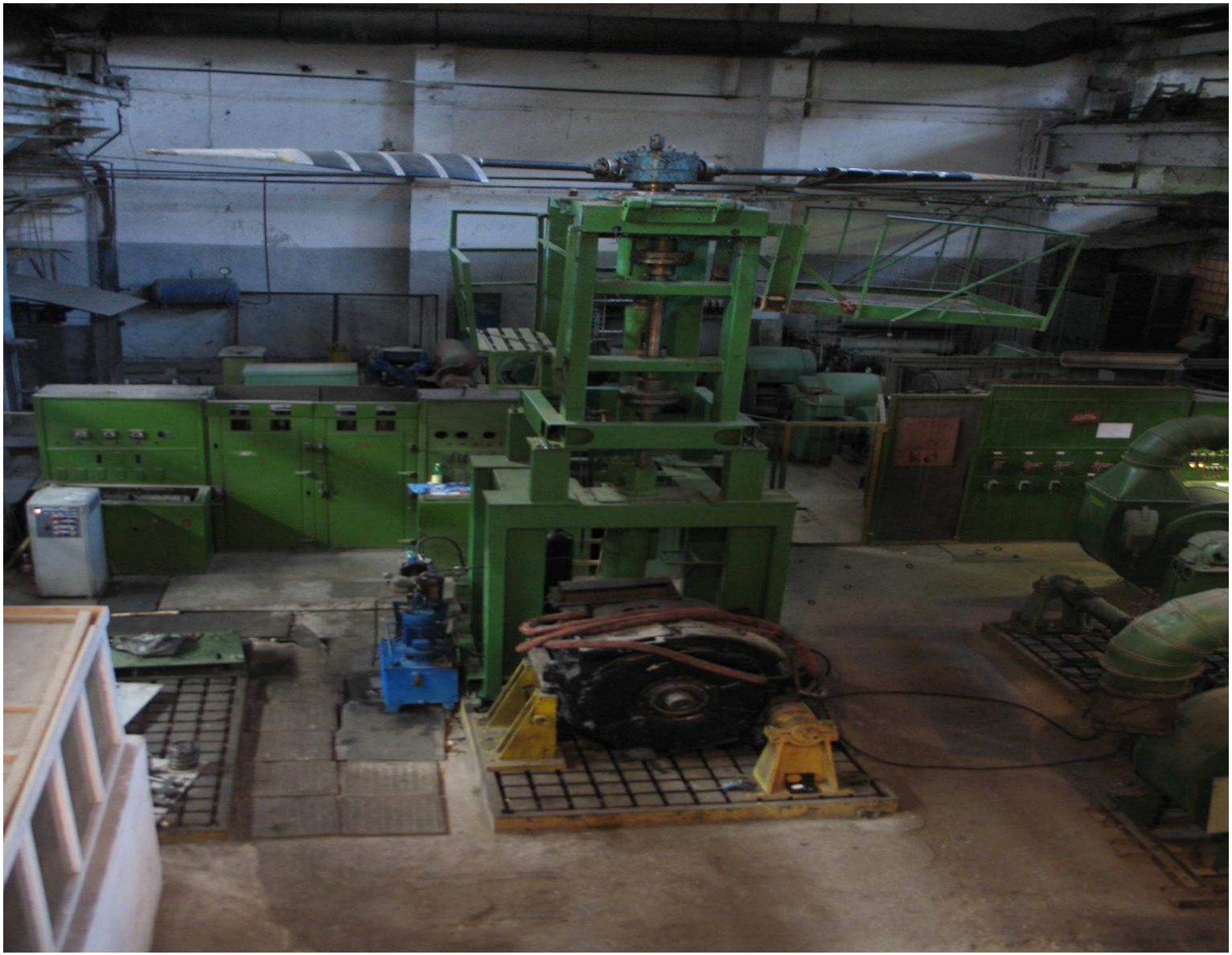
1-electric engine, 2-conical reducer, 3-transmission, 4-cylindric reducer, 5-control reducer, 6-frames, 7-mechanism of compensation of centrifugal forces, 8-hub, 9-blades.



Project G-1600. Schematic arrangement of the stand.
1-Electrical engine of direct current, 2-Conical reducer, 3-Cylindrical reducer, 4-Spindle of cylindrical reducer, 5-Blade with flexible elements, 6-Rope, 7-Unit of bearings with body, 8-Rod, 9-Piston, 10-Hydro-pneumo-accumulator, 11-Hydro-cylinder, 12-Hydro-distributor, 13-Unit of the rope mount.



Project G-1600. Stand for dynamic tests of the VGR.
Blades in retracted position.



Project G-1600. Stand for dynamic tests of the VGR.
Blades in extended position.

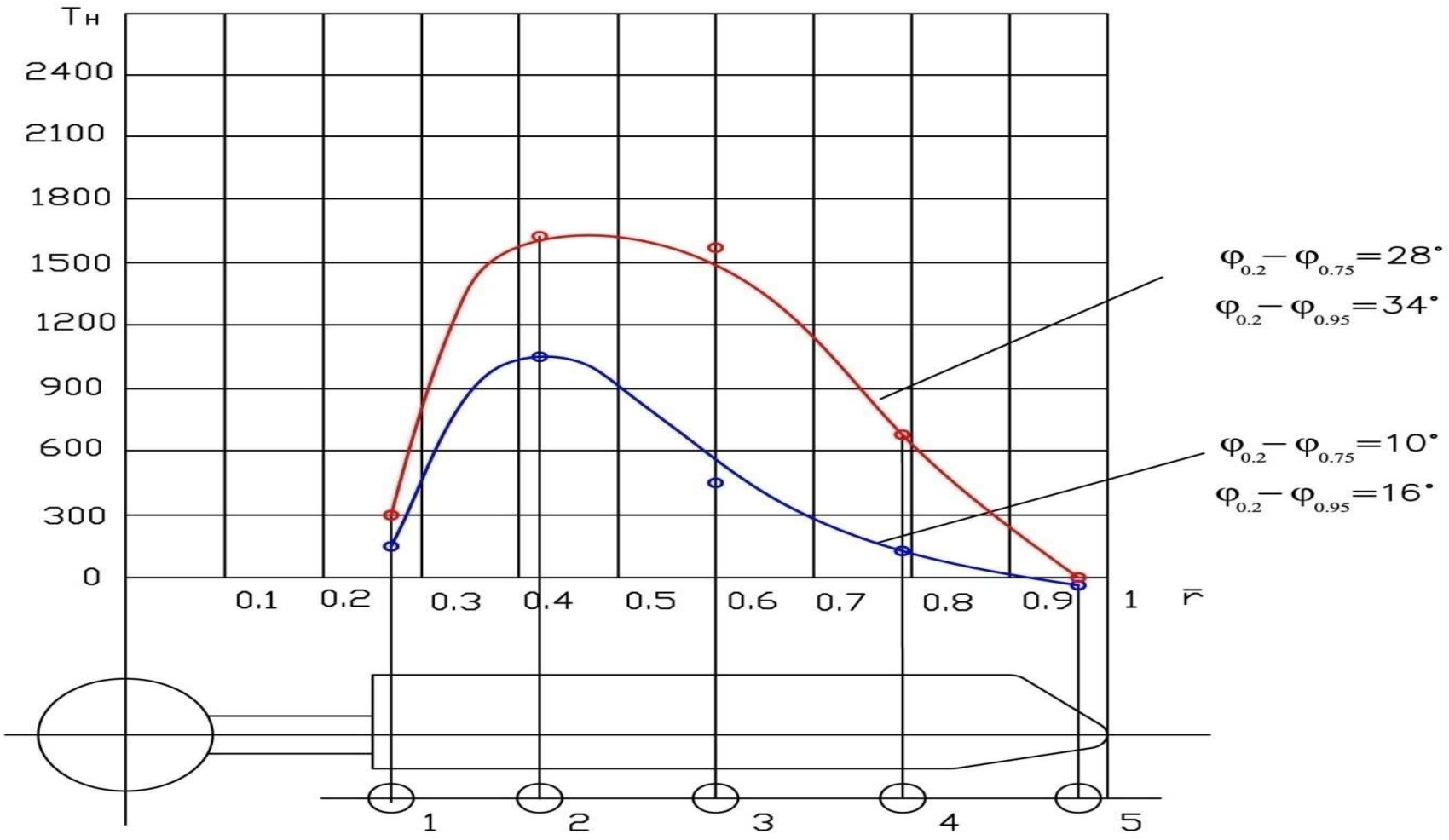


Diagram of dependence of the VGR thrust from the blade twist change for the minimum diameter D_{min} of the rotor, rotational speed, n=300 RPM and setting angle $\varphi=0^0$.

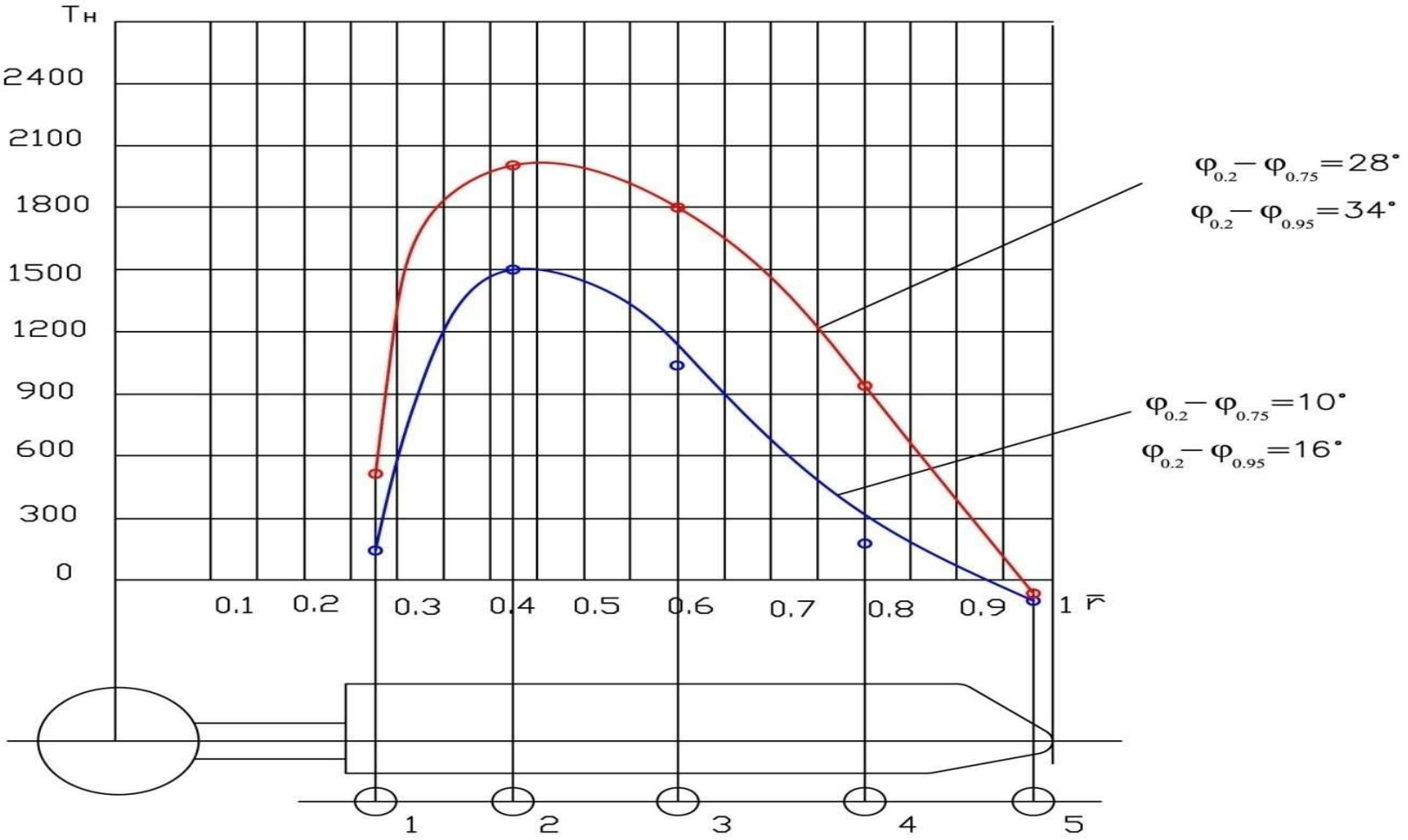


Diagram of dependence of the VGR thrust from the blade twist change for the minimum diameter D_{min} of the rotor, rotational speed, n=300 RPM and setting angle.

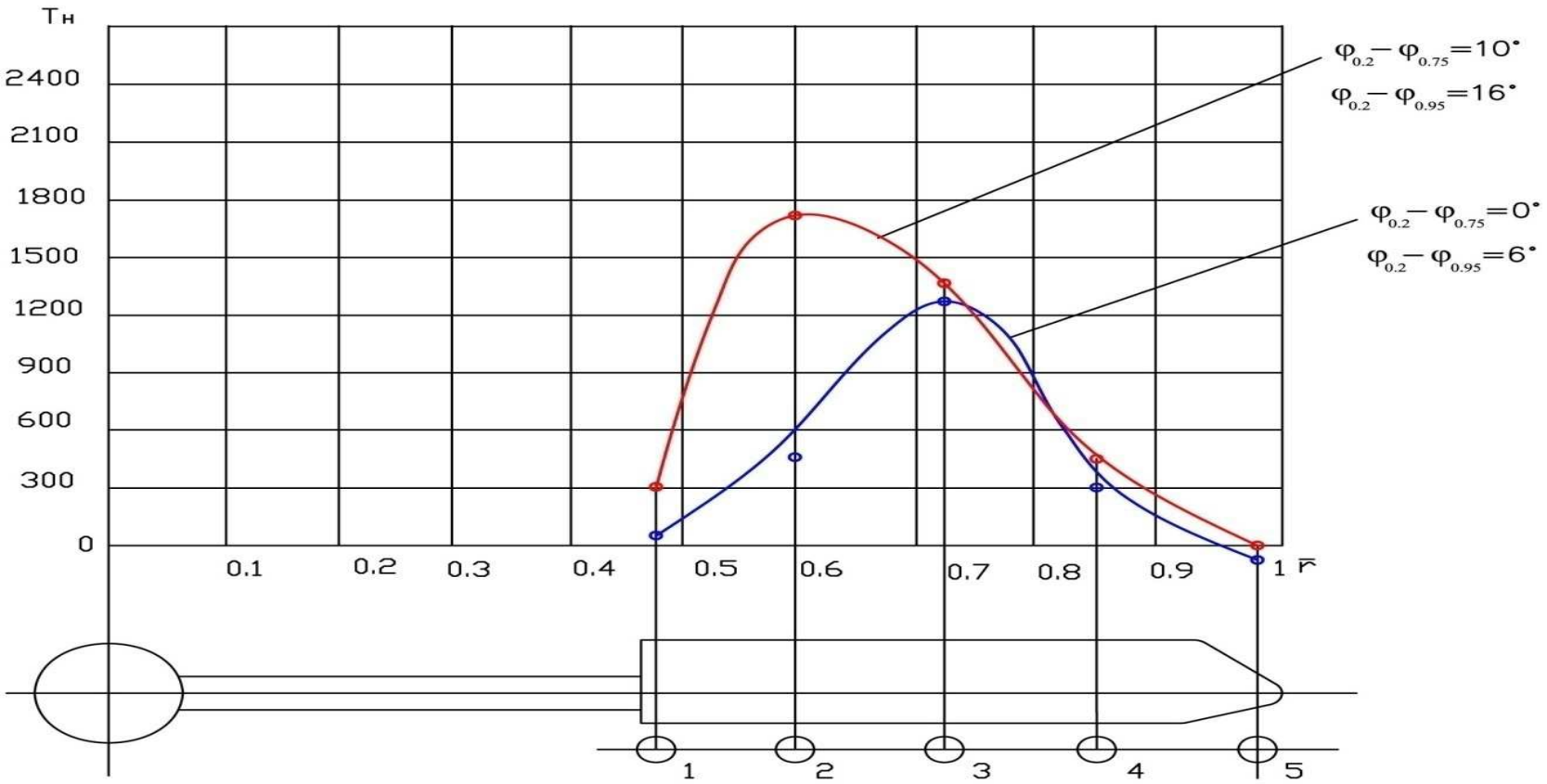


Diagram of dependence of the VGR thrust from the blade twist change for the maximum diameter D_{max} of the rotor, rotational speed, n=200 RPM and setting angle $\varphi=0^0$.

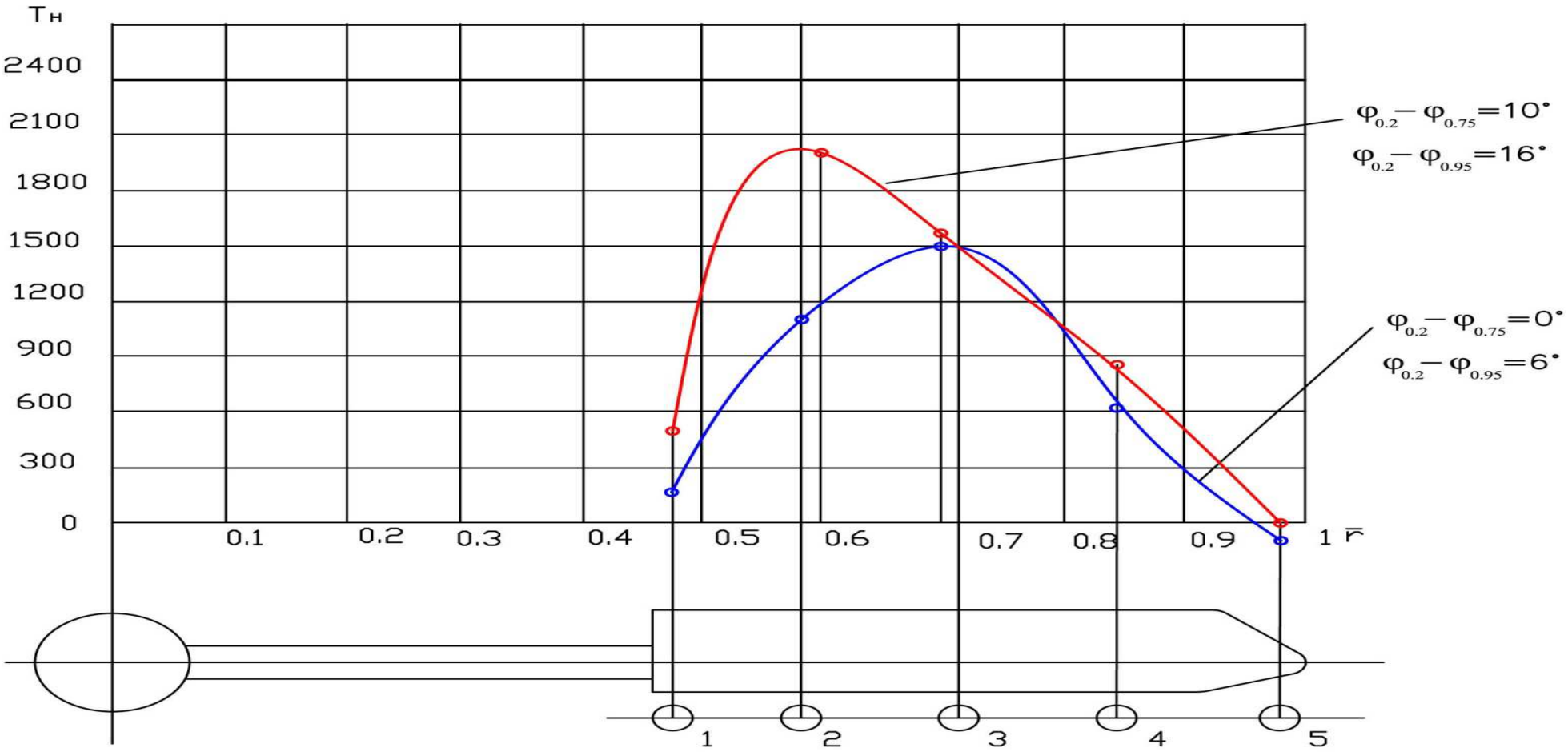


Diagram of dependence of the VGR thrust from the blade twist change for the maximum diameter D_{max} of the rotor, rotational speed, n=200 RPM and setting angle $\varphi=5^0$.

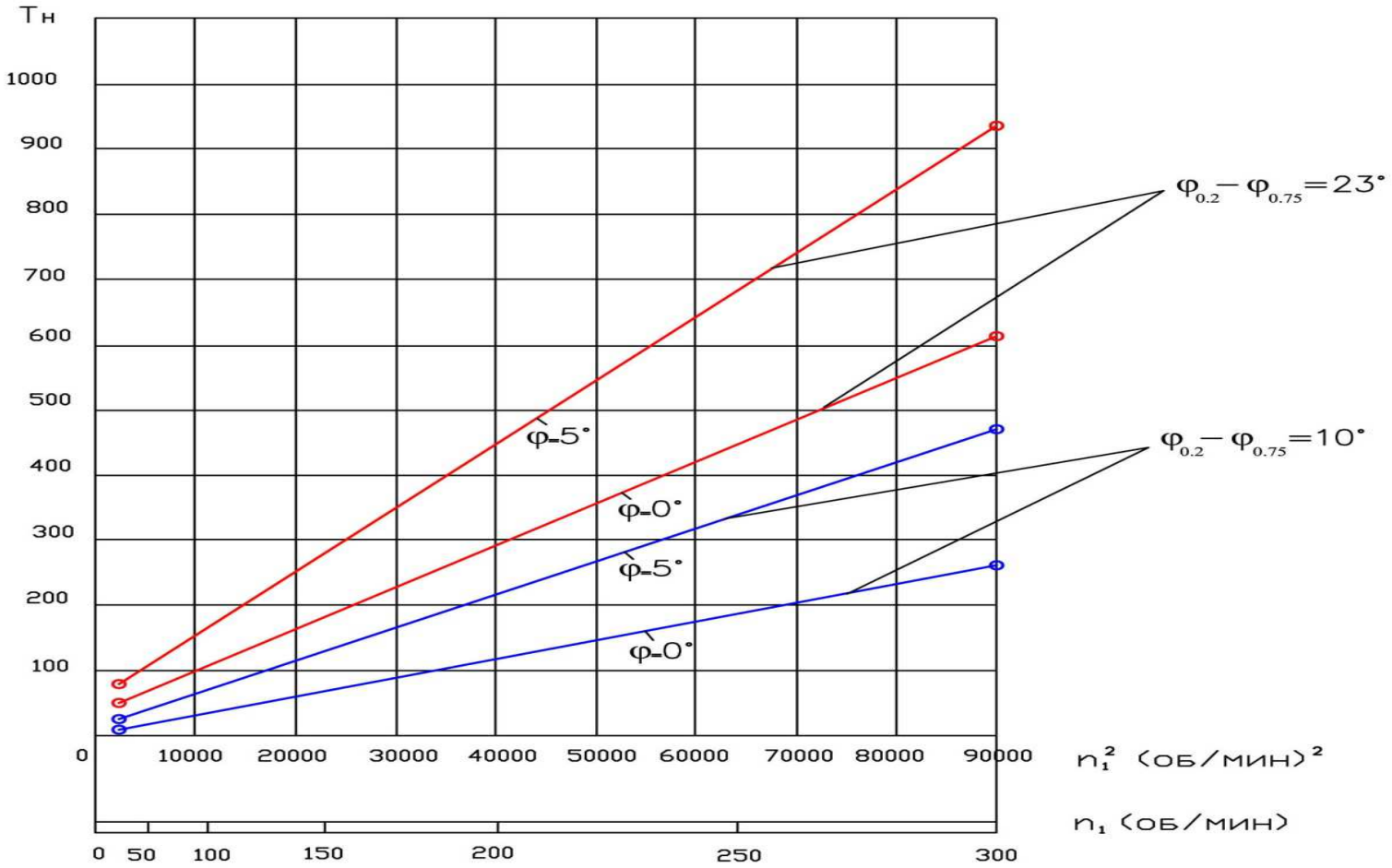


Diagram of dependence of the VGR thrust from the rotor rotational speed for the minimum diameter D_{min}

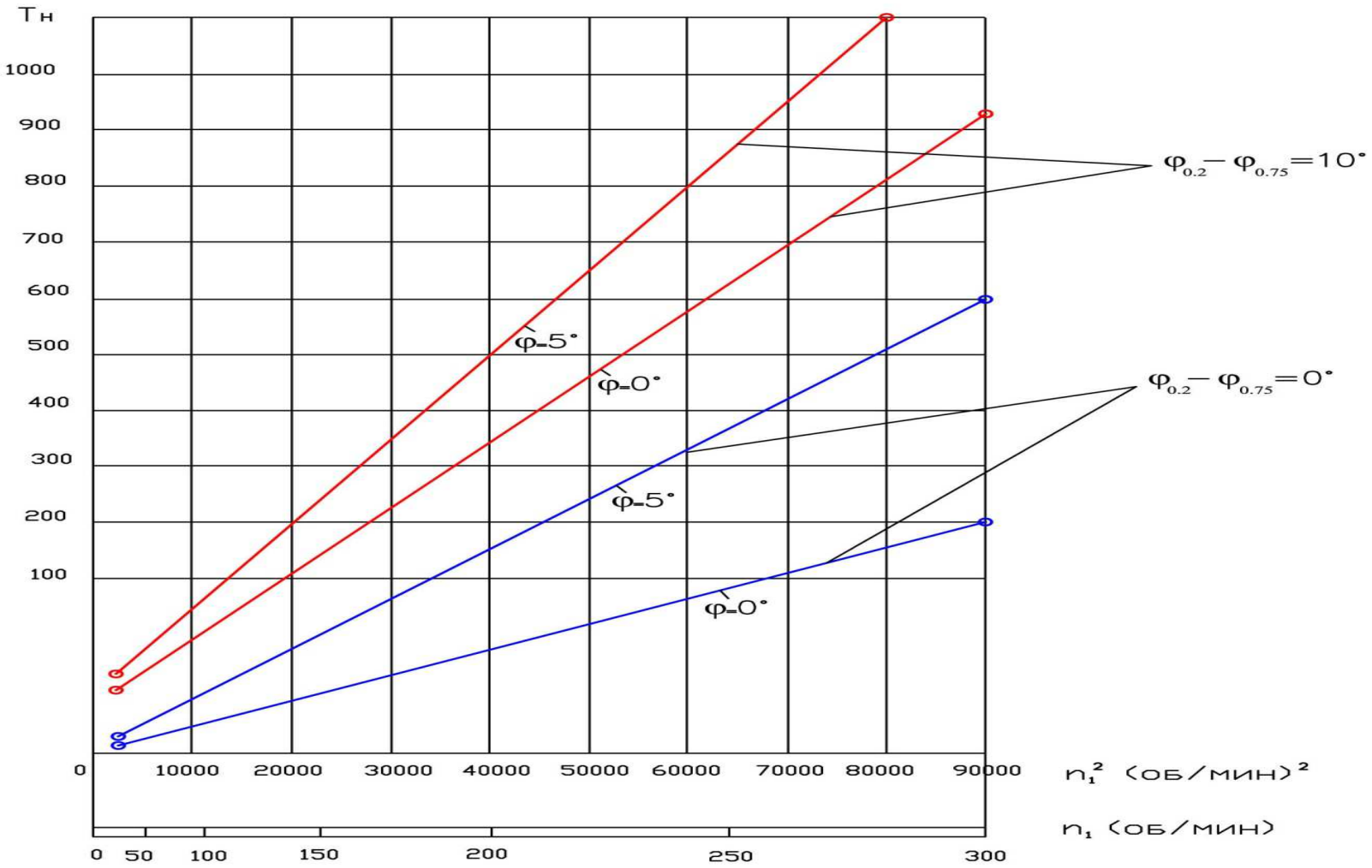


Diagram of dependence of the VGR thrust from the rotor rotational speed for the maximum diameter D_{min}

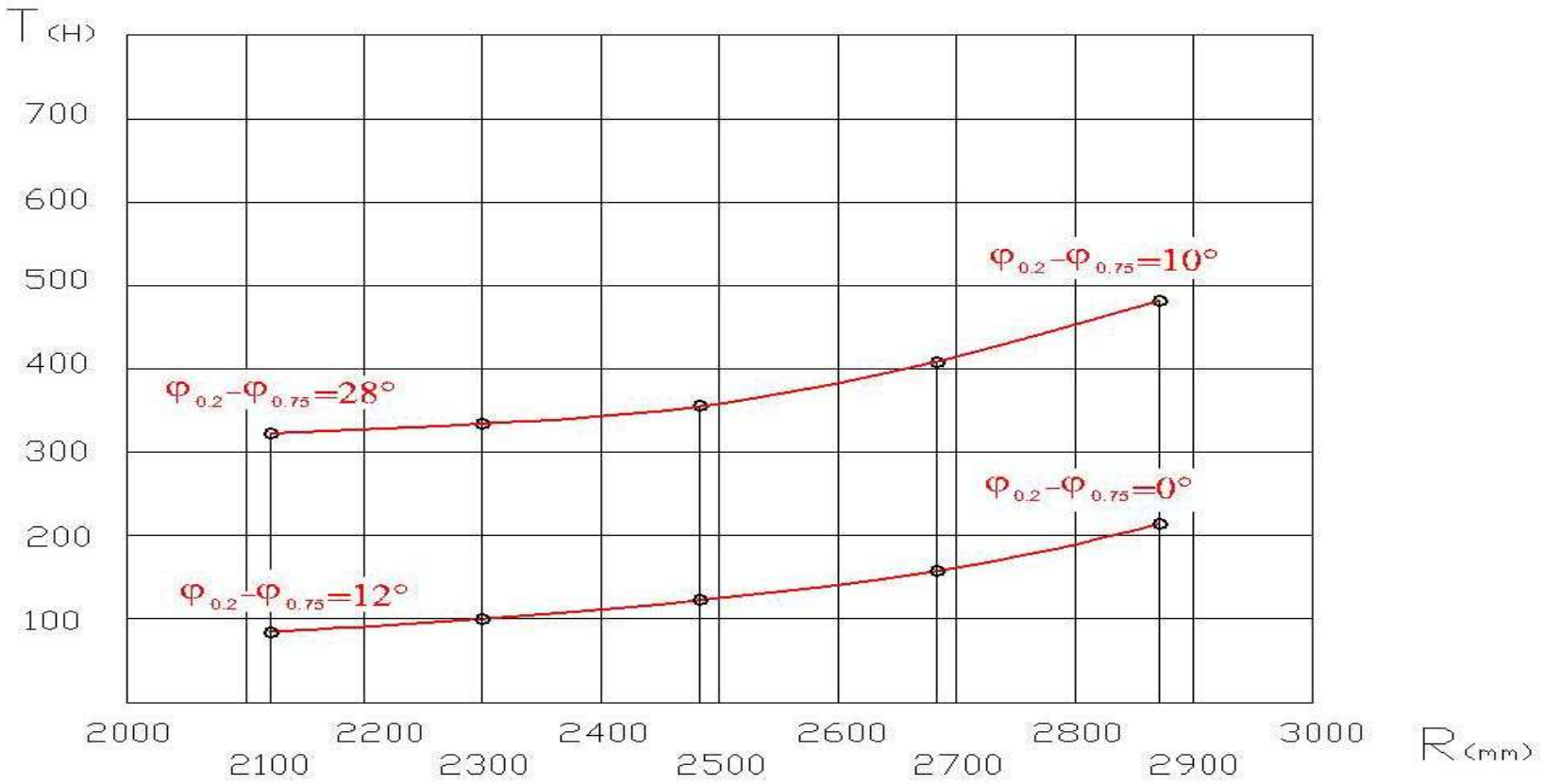


Diagram of dependence of the VGR thrust from diameter with simultaneous change of twist at rotational speed n=200 RPM and blade setting angle φ=0°.

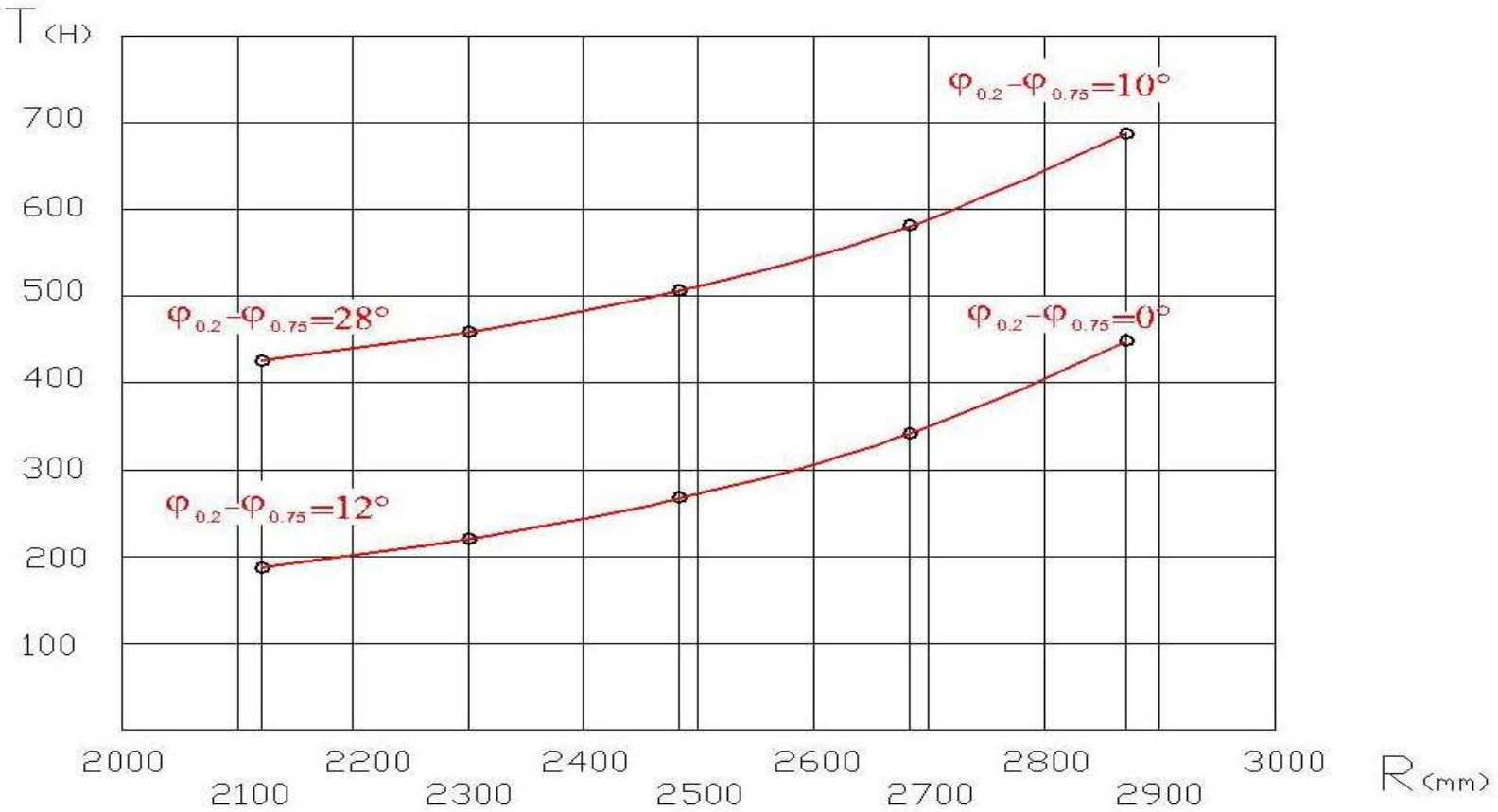


Diagram of dependence of the VGR thrust from diameter with simultaneous change of twist at rotational speed n=200 RPM and blade setting angle φ=5°.

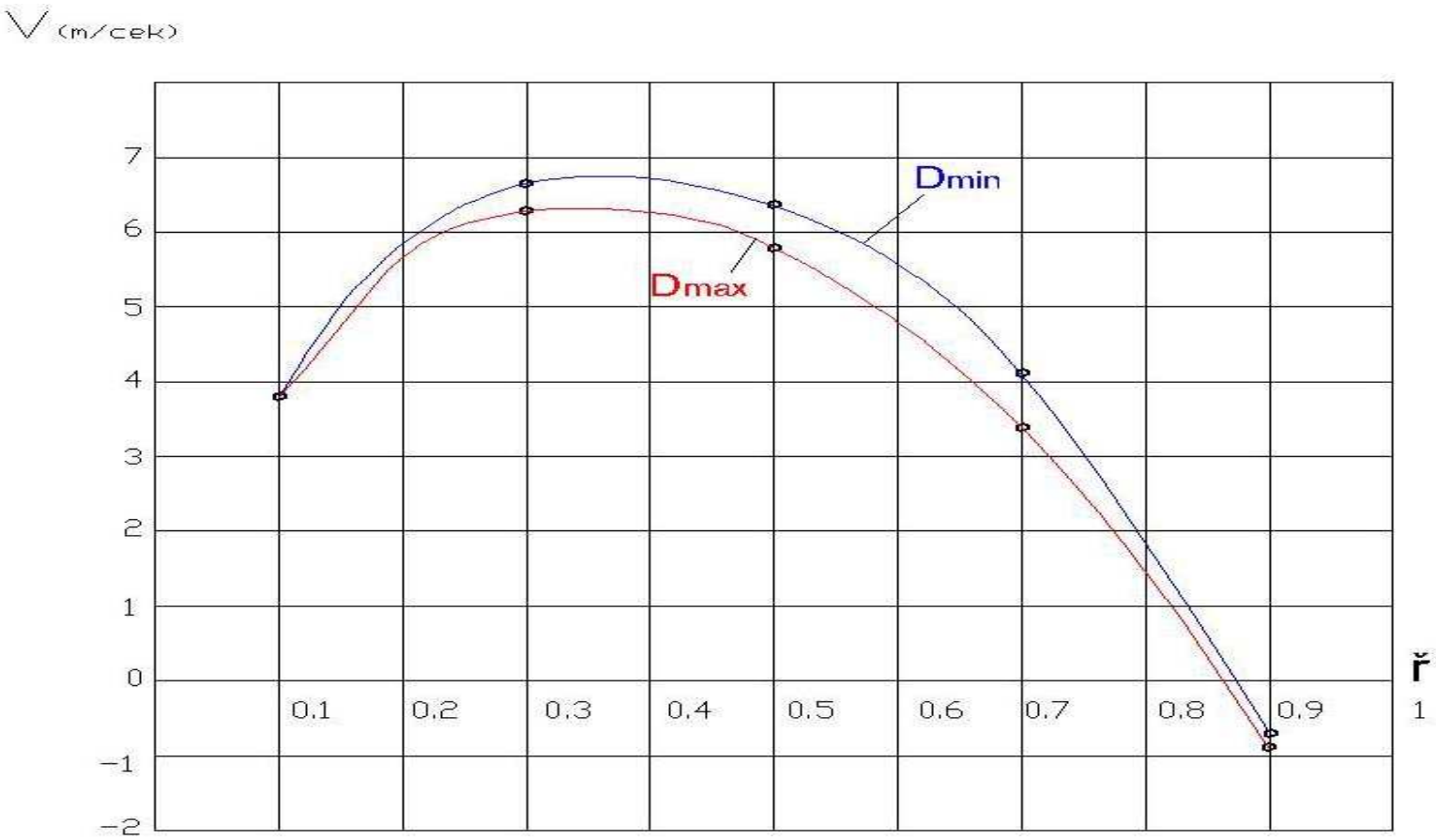


Diagram of distribution of induced speeds along the blade span for the rotor different diameters at rotational speed n=200 RPM and setting angle of blades φ=0°

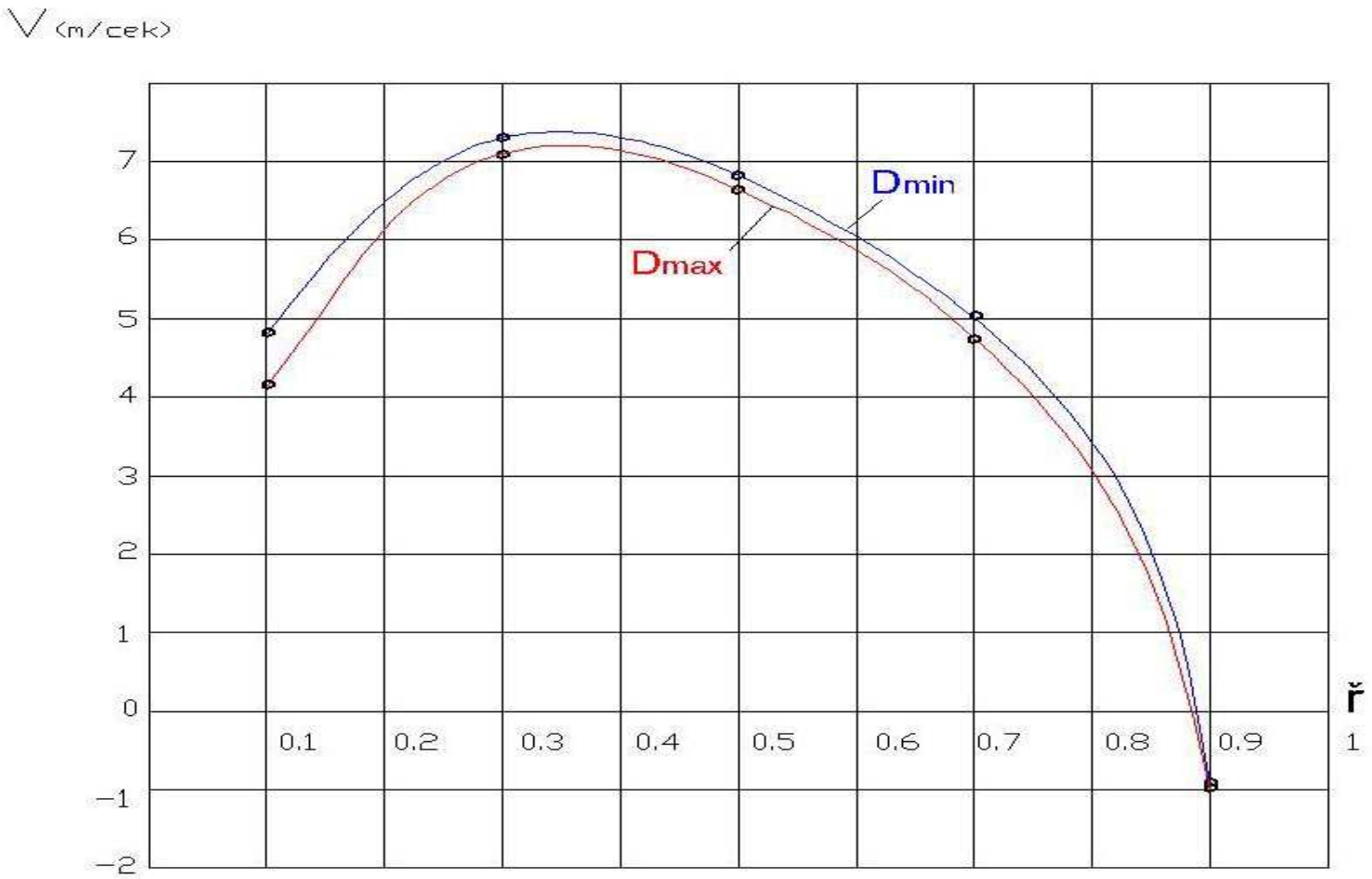
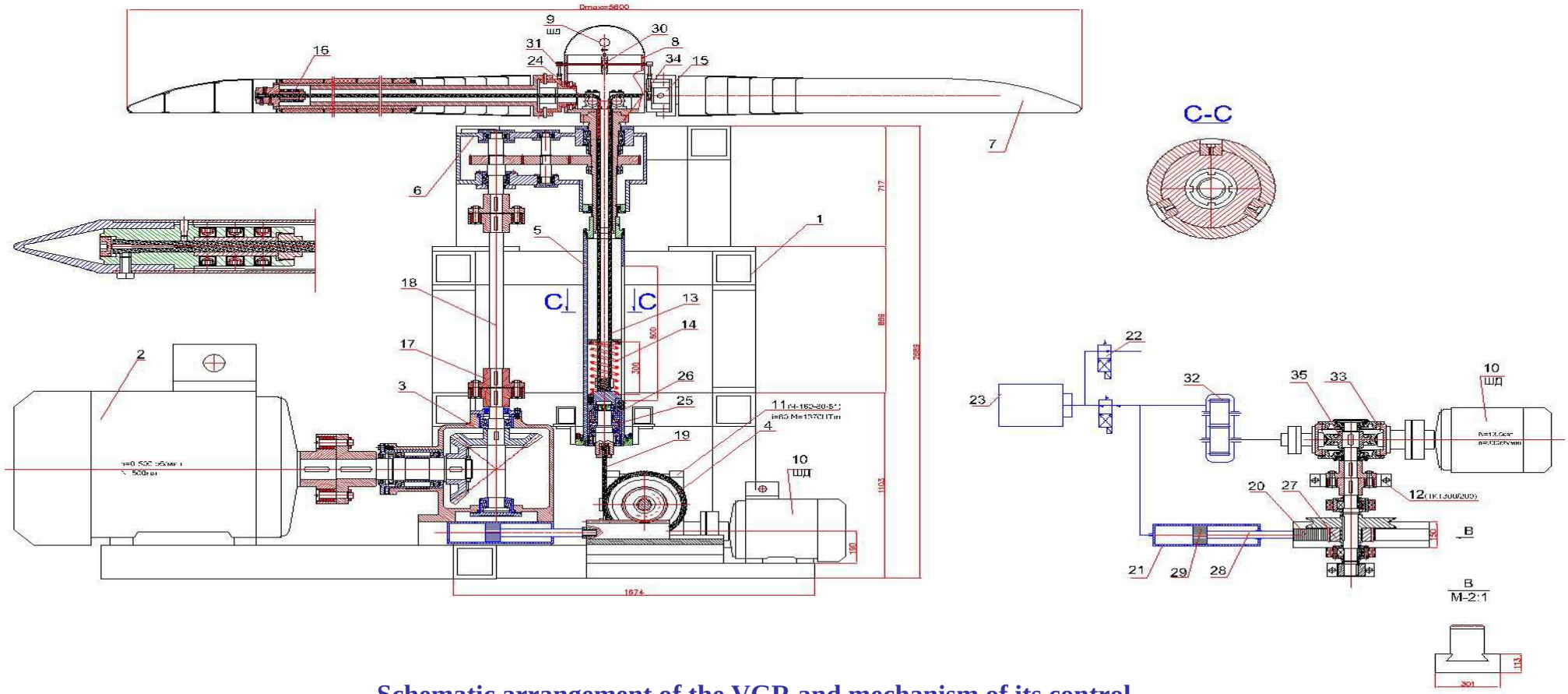
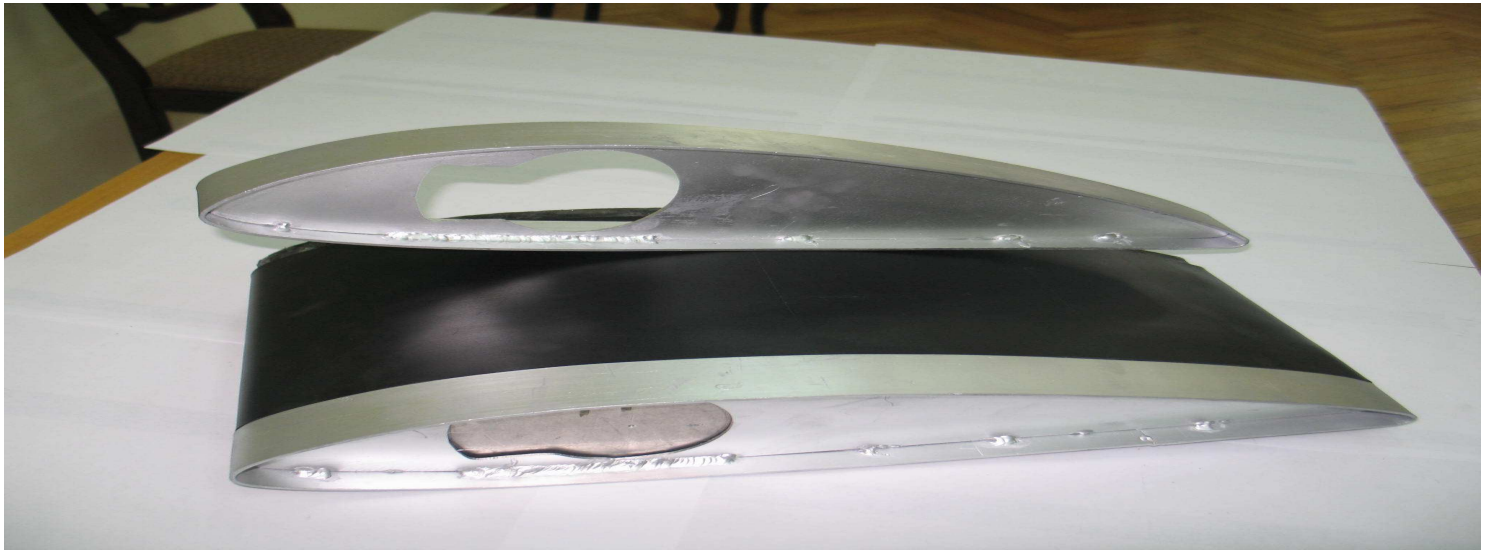


Diagram of distribution of induced speeds along the blade span for the rotor different diameters at rotational speed n=200 RPM and setting angle of blades φ=5°

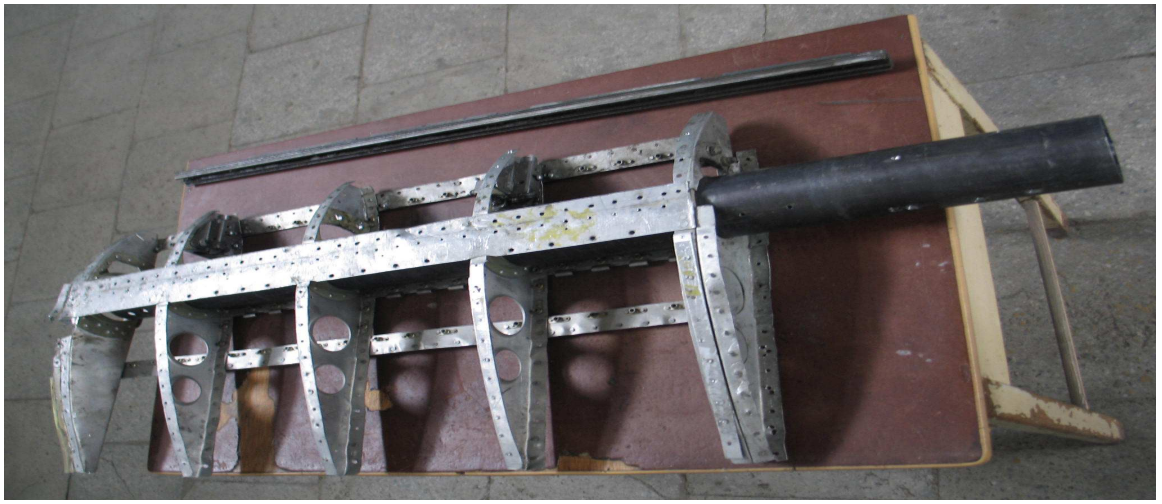


Schematic arrangement of the VGR and mechanism of its control

1-Body, 2-Drive, 3-Conical reducer, 4-Drum, 5-Guiding, 6-Cylindrical reducer, 7-Blade, 8-Hub, 9-Pitch engine for change of the blade setting angle, 10-Pitch engine, 11-Worm reducer Ч160-80-51,12-Shoe brake ТКТ300/200, 13-Cable ЛКО (ЛКО 6х20=114 Q=25,95т ГОСТ 3077-90), 14-Compensation unit of centrifugal forces, 15-Horizontal hinge of blade, 16-Mount unit of the cable, 17-Resilient coupling, 18-Shaft, 19-Drive cable (ЛКО 6х20=114 Q=25,95т ГОСТ 3077-90), 20-Rack pair m=4mm, 21-Hydro-cylinder, 22-Hydro-distributor, 23-Hydro-pneumo-accumulator, 24-Pulley, 25-Thrust bearing, 26-Radial bearing, 27-Rack wheel, 28-Rod, 29-Piston, 30-Worm pair, 31-Lever, 32-Gear pump, 33-Worm reducer, 34-Spindle, 35-Worm.



Elastic elements of the blade flexible parts



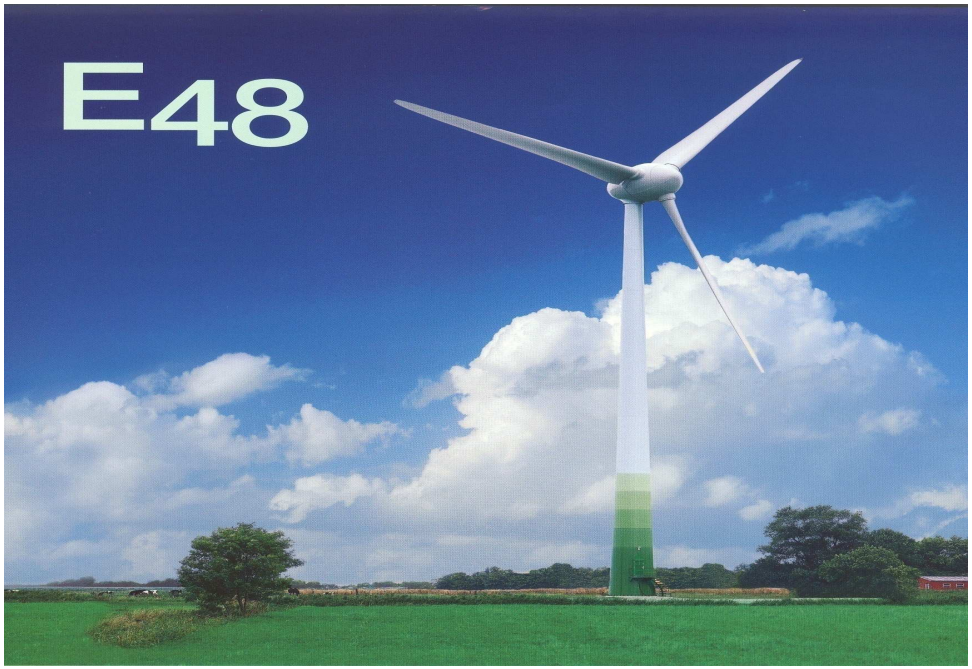
Process of assemblage of the blade

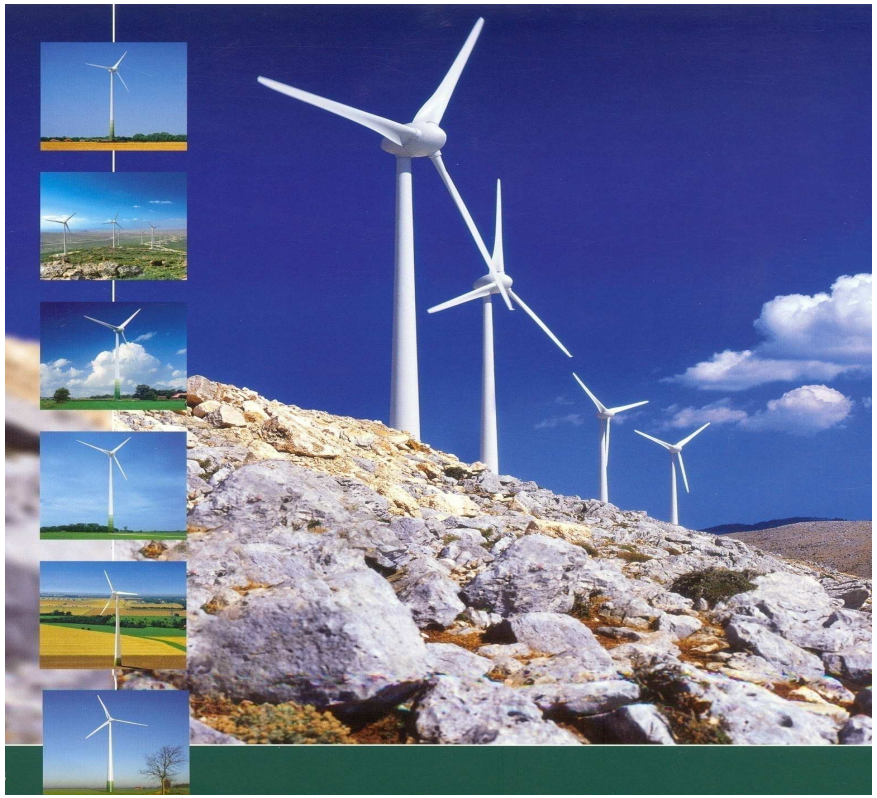
Blade with ribs without flexible elements on the stand for static investigations

Project G-1600. Stand for VGR static tests

Areas of application of the rotors with variable parameters in dynamics

Wind Energy






E44

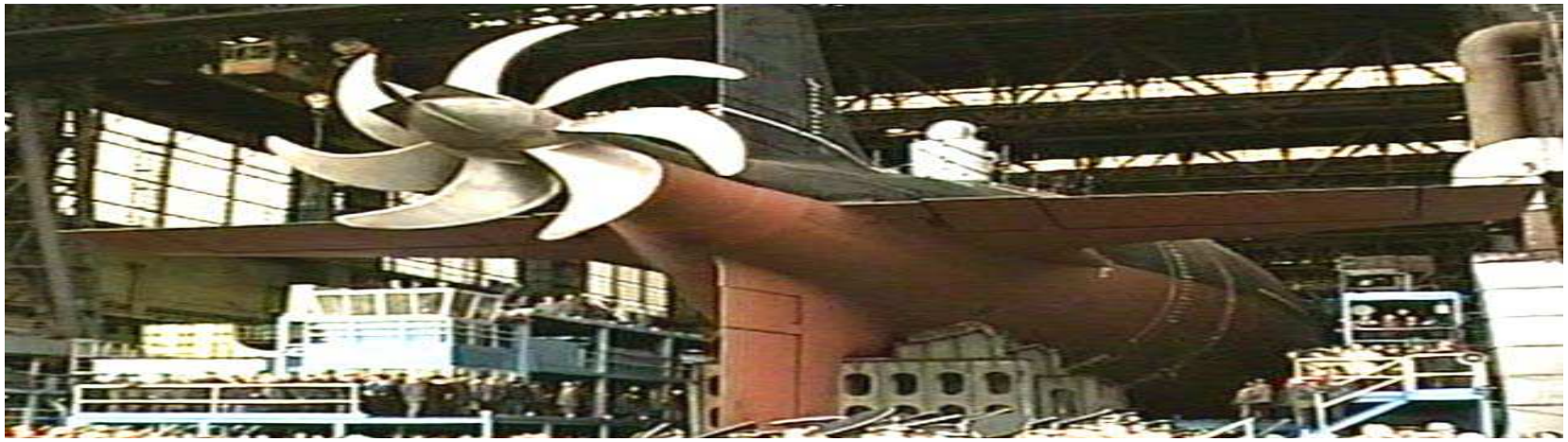
Airplanes with vertical takeoff and landing

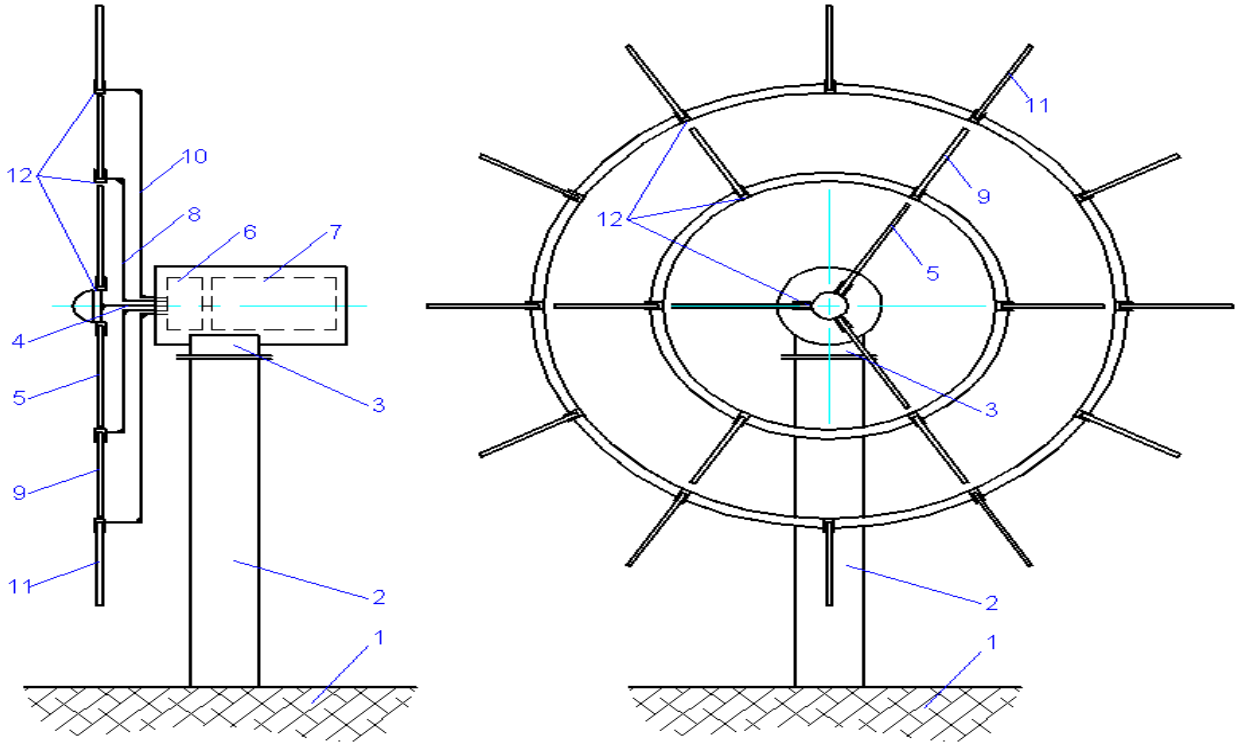

BAGOS
N60STR
Tilt Rotor

Helicopters

Dirigible building

Ship building – Water transport





Multi-step Rotor for Wind Energy Installations

THANK

YOU

FOR

ATTENTION!!!