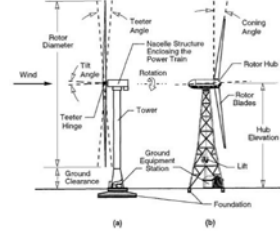




İYTE  
YELKAPAN TEKNOLOJİSİ  
SEMİNERLERİ  
- KOMPONENTLER -

Ercüment Ayanak  
Makina Y. Mühendisi  
Urla, 29.Kasım.2012

YELKAPAN TEKNOLOJİSİ  
YATAY EKSENLİ YELKAPANLAR



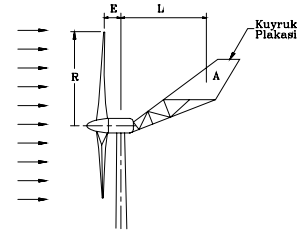
Horizontal Axis Wind Turbine  
UPWIND DESIGN & DOWNWIND DESIGN  
Önden Rüzgarlı & Arkadan Rüzgarlı  
Tertip Tertip

YELKAPAN TEKNOLOJİSİ  
YAW TECHNICS & YÖNELTME TEKNİKLERİ



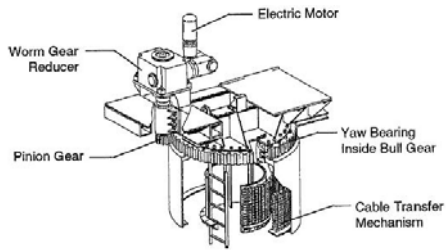
Passive Yaw Drive System - I  
DOWN-WIND DESIGN  
Arkadan Rüzgarlı Tertip

YELKAPAN TEKNOLOJİSİ  
YAW TECHNICS & YÖNELTME TEKNİKLERİ



Passive Yaw Drive System - II  
TAIL VANE  
Kuyruk Plakası

YELKAPAN TEKNOLOJİSİ  
YAW TECHNICS & YÖNELTME TEKNİKLERİ



ACTIVE YAW DRIVE SYSTEM

YELKAPAN TEKNOLOJİSİ  
YAW TECHNICS & YÖNELTME TEKNİKLERİ

Mobile Equipment and Wind Energy Solutions

**700T series** Yaw and Pitch Drive for Wind Turbines

Torque Range: 8,000 ... 200,000 Nm  
Gear Ratios: 1:1 ... 200:1  
Key Features:  
- Flange mounted  
- Output shaft: splined or with integral pinion  
- Rugged construction  
- High torsion capacity  
- Output shafts supported by heavy-duty bearings  
Applicable AC motors:  
- Compact motor and brake motors, M series  
- B.C. motor and brake motors, B6 series  
Main Motor Features:  
- DC and AC type  
Main Motor Options:  
- Thermistor and thermostat sensors

ACTIVE YAW DRIVE SYSTEM  
BONFIGLIOLI YAW DRIVE MOTORS / ITALY

**YELKAPAN TEKNOLOJİSİ**  
**YAW TECHNICS & YÖNELTME TEKNİKLERİ**

(a) (b)

Figure 4-13. Schematic diagram of a motor-driven yaw system. (a) Electric or hydraulic motor drive and pinion gear (b) Ball gear and yaw bearing assembly.

**ACTIVE YAW DRIVE SYSTEM**

**YELKAPAN TEKNOLOJİSİ**  
**BEARING DESIGNS & RULMAN TASARIMLARI**

Fig. 32

**ROTHER ERDE BEARING DESIGNS**

**YELKAPAN TEKNOLOJİSİ**  
**BEARING DESIGNS & RULMAN TASARIMLARI**

**ROTHER ERDE BEARING DESIGNS**

**YELKAPAN TEKNOLOJİSİ**  
**BEARING DESIGNS & RULMAN TASARIMLARI**

**ROTHER ERDE BEARING DESIGNS**

**YELKAPAN TEKNOLOJİSİ**  
**BEARING DESIGNS & RULMAN TASARIMLARI**

**ROTHER ERDE BEARING DESIGNS**

**YELKAPAN TEKNOLOJİSİ**  
**BEARING DESIGNS & RULMAN TASARIMLARI**

Figure 1: old design      Figure 2: better design

**Moment Load**      **Moment Load**

YELKAPAN TEKNOLOJİSİ  
BEARING DESIGNS & RULMAN TASARIMLARI

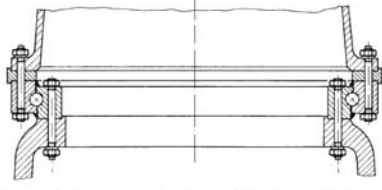


Figure 8.49. Single-row four-point ball-bearing in the rotor blades of the earlier WKA-60 (Rohde & Edde Schmiedag AG)

BLADE BEARING DESIGN

YELKAPAN TEKNOLOJİSİ  
BEARING DESIGNS & RULMAN TASARIMLARI



BLADE PITCH DRIVE & BEARING  
ROTOR HUB / PERVANE GÖBEĞİ

YELKAPAN TEKNOLOJİSİ  
BEARING DESIGNS & RULMAN TASARIMLARI

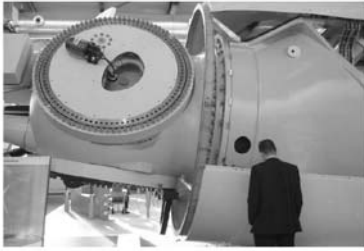


Figure 8.48. Cast load-bearing structure with in-plane rotor bearing on a Vestas V-90 (Gleitsch, Vestas)

ROTOR HUB / PERVANE GÖBEĞİ

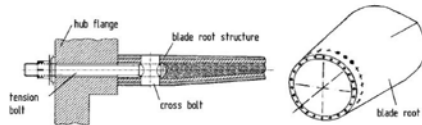
YELKAPAN TEKNOLOJİSİ  
BLADE ROOT CONNECTIONS



Figure 2.44. Rotor blade connection to the hub in the Vestas V-90 rotor blade

BLADE ROOT / PALA KÖKÜ

YELKAPAN TEKNOLOJİSİ  
BLADE ROOT CONNECTIONS



BLADE ROOT DESIGN

YELKAPAN TEKNOLOJİSİ  
BLADE ROOT CONNECTIONS



Figure 2.44. Blade connection with cross-bolts

(MBB)

BLADE ROOT DESIGN

YELKAPAN TEKNOLOJİSİ

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BLADE ROOT CONNECTIONS

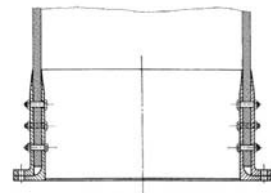


Figure 2-36. Heavy dual steel flange in earlier rotor blades (LM)

OLD DESIGN

YELKAPAN TEKNOLOJİSİ

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BLADE DESIGN

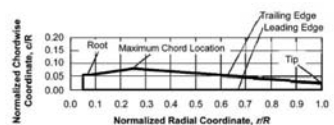


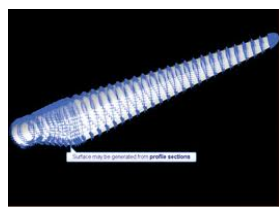
Figure 2-6. Typical normalized platform shape of a wind turbine blade. [Griffin 2001]

TAPER OF THE BLADE

YELKAPAN TEKNOLOJİSİ

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BLADE DESIGN

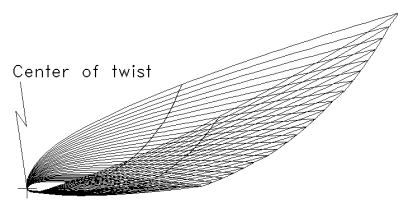


STATIONS OF BLADE

YELKAPAN TEKNOLOJİSİ

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BLADE DESIGN

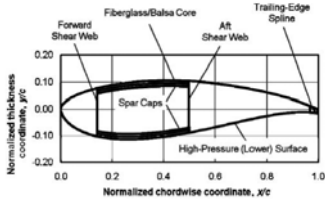


TWIST OF THE BLADE

YELKAPAN TEKNOLOJİSİ

---

BLADE DESIGN




BLADE CROSS-SECTION  
AIRFOIL FORM / DAMLAFORM

YELKAPAN TEKNOLOJİSİ

---

BLADE DESIGN



AIRFOIL FAMILY  
TIP / PRIMARY / ROOT

YELKAPAN TEKNOLOJİSİ

---

BLADE DESIGN

The diagram illustrates the aerodynamic forces on a wind turbine airfoil. It shows the wind direction, the plane of rotation, the angle of attack  $\alpha$ , the angle of the airfoil chord line  $\beta$ , and the angle of the resultant force  $F_R$ . Forces shown include lift  $F_L$ , drag  $F_D$ , and the resultant force  $F_R$ . The center of pressure is also indicated. The direction of tangential velocity is shown as  $v$ .

AIRFOIL AERODYNAMICS

YELKAPAN TEKNOLOJİSİ

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BLADE DESIGN

The diagram shows a wind turbine blade with a twist. It illustrates the wind direction  $v$  and the direction of rotation  $\Omega$ . The relative velocity angle changes along the length of the blade due to the combination of wind speed and the tangential velocity  $R\Omega$  at different radii  $R$ .

TWIST OF THE BLADE  
(RELATIVE VELOCITY ANGLE CHANGES..!)

YELKAPAN TEKNOLOJİSİ

---

BLADE DESIGN

Figure 2-1 shows a photograph of a flexible rotor blade tip. The y-axis is labeled "Normalized Chordwise Coordinate,  $x/c$ ".

Figure 2-6. Flexible rotor blade tip for aerodynamic overspeed limitation.

AERODYNAMIC TIP BRAKE  
(OVERSPEED CONTROL)

YELKAPAN TEKNOLOJİSİ

---

BLADE DESIGN

Figure 4-11 shows tip devices for overspeed control. (a) Tip brake (b) Pitchable tip.

Figure 4-11. Tip devices for overspeed control in the undeployed (left) and deployed (right) positions. (a) Tip brake (b) Pitchable tip.

AERODYNAMIC TIP BRAKE  
(OVERSPEED CONTROL)

YELKAPAN TEKNOLOJİSİ

---

BLADE DESIGN

Figure 7-25 shows a rotor blade tip with a hydraulic resetting system. Components include a hydraulic line, restoring cylinder, prestressing spring, and centrifugal weight (blade tip).

Figure 7-25. Rotor blade tip with hydraulic resetting system. (LM)

AERODYNAMIC TIP BRAKE  
(OVERSPEED CONTROL)

YELKAPAN TEKNOLOJİSİ

---

BLADE DESIGN

Figure 7-28 shows lightning protection for a rotor blade. Components include a receptor, lightning conductor, registration card, and flexible metallic strips (lightning transfer).

Figure 7-28. Lightning protection of a rotor blade. (LM)

LIGHTNING PROTECTION  
(YILDIRIMDAN KORUMA)

**YELKAPAN TEKNOLOJİSİ**

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**BLADE DESIGN**

Figure 239. Electrical heating system for rotor blade de-icing (LM)

**DE-ICING SYSTEM - I  
(BUZLANMA ÖNLEYİCİ SİSTEM)**

**YELKAPAN TEKNOLOJİSİ**

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**BLADE DESIGN**

Figure 230. Rotor blade root section with the de-icing system using hot air (ENERCON)

**DE-ICING SYSTEM - II  
(BUZLANMA ÖNLEYİCİ SİSTEM)**

**YELKAPAN TEKNOLOJİSİ**

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**BLADE SUPPLIERS**

Range of products			
Blade length 6000 - 13575 m	Blade height 100 - 300 m	Blade height 300 - 1000 m	Blade height 1000 - 1200 m

**EUROS / ALMANYA  
LM / DANİMARKA**

**YELKAPAN TEKNOLOJİSİ**

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**BLADE MANUFACTURING**

Bild 2.14. Fully mechanised production of the rotor blade of the WTS-3 [7]

1. Winding the D-spar
2. Placing the cores for the rear box
3. Winding the complete blade

**YELKAPAN TEKNOLOJİSİ**

---

**BLADE MANUFACTURING**

Figure 2.15. Rotor blade of the WTS-3 turbine on the winding machine (Hamilton Standard)

**YELKAPAN TEKNOLOJİSİ**

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**BLADE MANUFACTURING**

Figure 2.17. Rotor blade production at ENERCON (ENERCON)

YELKAPAN TEKNOLOJİSİ  
BLADE MANUFACTURING



YELKAPAN TEKNOLOJİSİ  
BLADE TRANSPORT



Figure 4-16. Specialized wheeled fixtures are required for transporting very long wind turbine blades. The blade shown here is 61.5 m long. (Courtesy of LM Glasfiber)

YELKAPAN TEKNOLOJİSİ  
BLADE REPAIRING



ROPE ACCESS SERVICE