10kW Wind Turbine – Manual

Designed & Engineered by

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Thailand

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1 Introduction

10 kw wind machine is specialized in designing and manufacturing Grid-tied wind turbine inverters, photovoltaic inverters and renewable energy related generators. Most of our customers request us to design and manufacture small wind turbine systems and components that are less than 100kW configurations. Small wind turbine components are sold and shipped both domestically and internationally through our world-wide sales network.

This manual is contains information on installation and maintenance for the customer and dealer who intend to perform these services.

GENERAL FEATURES	
Rated Power	**10kW @ 9m/s**
Cut In	**2.5m/s**
Survival Wind Speed	**50m/s (without lowering the tower)**
IEC Turbine Class	**3**

[Table 1-1]

- Installation Planning

The location and height of the wind turbine tower are important factors to determine overall system performance for 10kW wind turbine system setting.

The wind speed and directions are affected by surrounding environment, especially for valley, desert and sub-sea regions. Since the change in wind velocity cannot be measured in real-time and apply toward the system design, data of average wind velocity is collected and applied as a vector quantity: hourly, daily, monthly, and yearly.

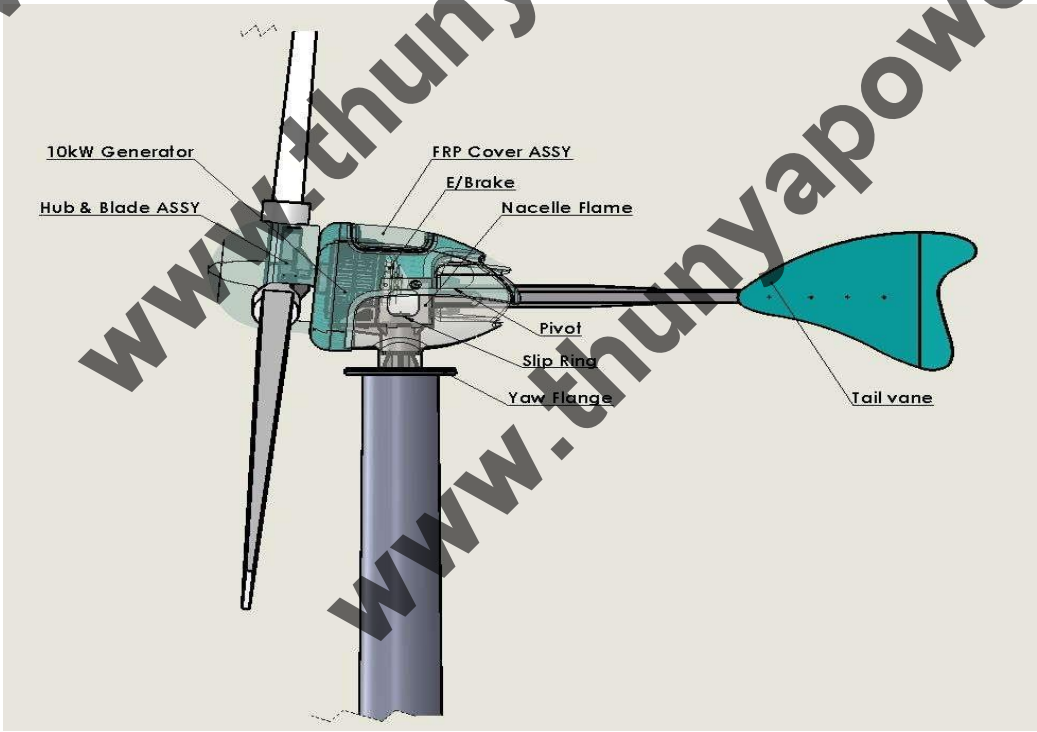
Installation site and height of the tower should be carefully selected considering all these factors stated above. Towers and blades of the 10kW for this Thailand's wind turbine power generation project will be manufactured in Prapai. Further details related to this project are confidentially kept within.

A. Structure

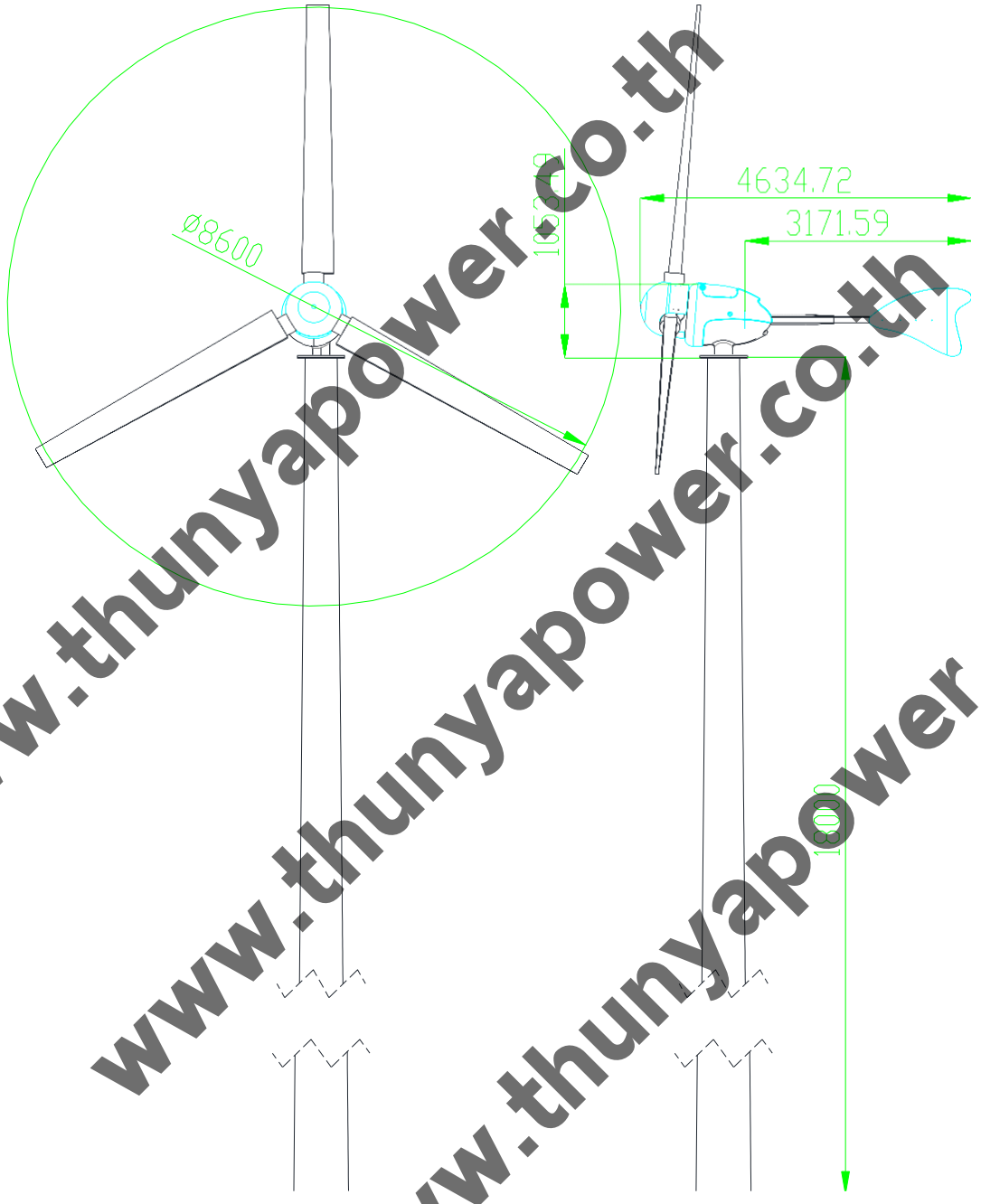
Individual component of wind turbine systems and overall system structures are listed on the table below.

No	Parts	Details	Quantity	
1	Blade Assembly	Blade	3	
		Hub	1	
		Nosecone	1	
2	PM Generator	12kW PM Generator	1	
3	Yaw System	Nacelle Frame	1	
		Yaw Flange	1	
		GFRP Cover	1	
		Slip Ring	1	
4	Excess Wind Control System	Tail Vane	1	
		Electromagnetic Brake	1	
		E/Brake Controller	1	
5	Tower	18 meter	1	

[Table 1-2]



[Fig. 1-1]



[Fig. 1-2]

2 Specifications

1. Blade Specifications

Blade Specifications are listed on the table below.

No	Items	Data
1	Number of blades	3
2	Rotor Diameter	8.6 m
3	Swept Area	58.1 m^2
4	Blade Material	Fiber glass reinforced epoxy
5	Rotor Position	Upwind
6	Tip Speed Ratio	7.5
7	Twist Angle	2 ~ 6°
8	Rotor Speed at Rated Output	120 rpm

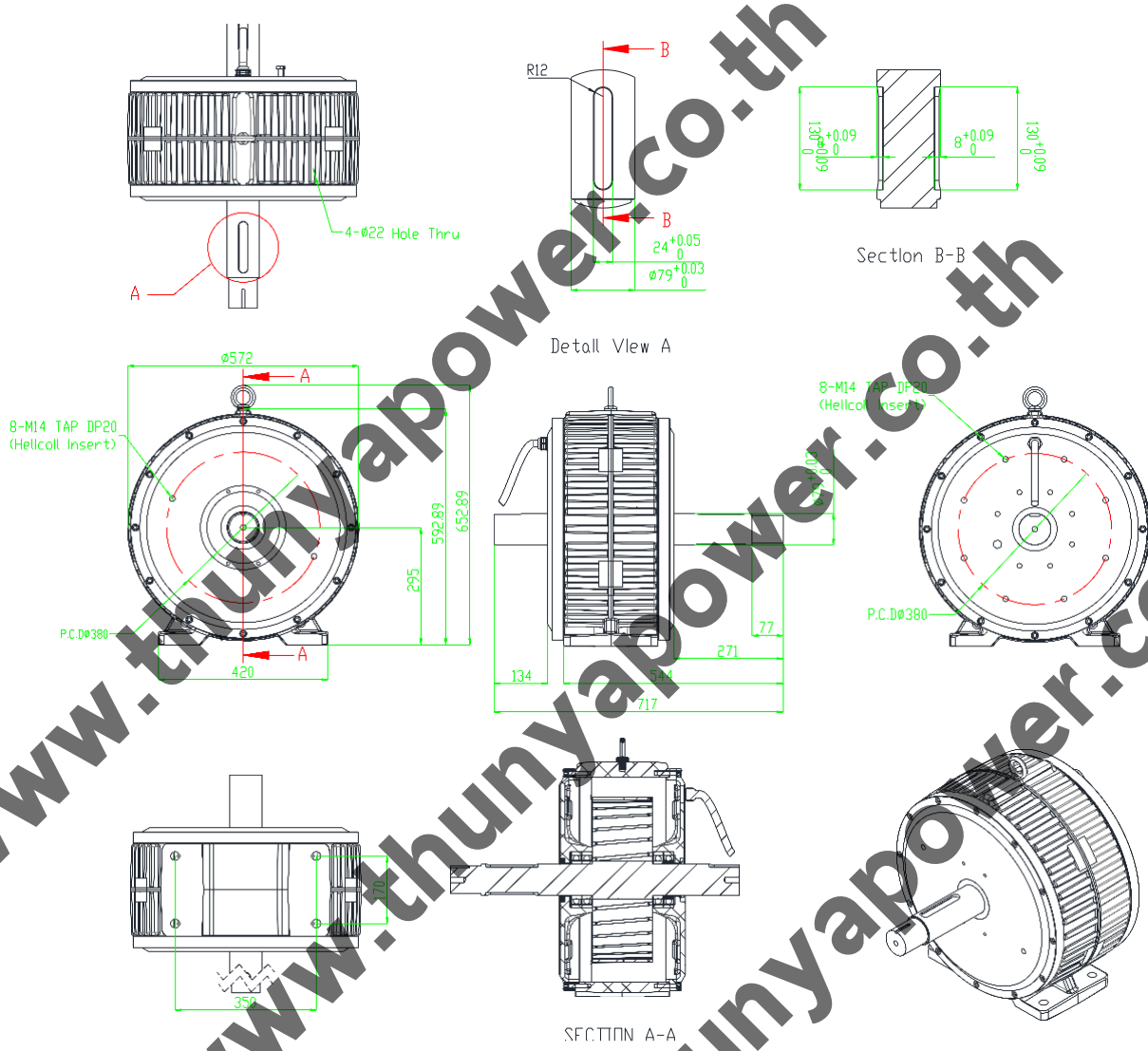
[Table 2-1]

[Fig. 2-1]

2. PM Generator Specifications

	Symbol	units	
Output power	Po	kW	12
Rated speed	w	rpm	120
Output Voltage	E	Vac	3phase, 360 (Line-to-Line)
Max. Efficiency	h	%	94
Rotor			Permanent magnet
Number of Pole	-	-	30
Constant Speed	K_E	Vdc/rpm	4.6
Resistance at 20 °C(Line-Line)	R_T	W	1.79
Inductance (Line-Line)	L	mH	24.9
Rotor Inertia	J	Kg-m^2	1.47
Maximum Temperature	C_{Max}	°C	150
Winding			Wye
Starting Torque		Nm	< 10
Shaft Play-Axial		mm	< 0.2
Gen. Weight	Wg	Kg	210

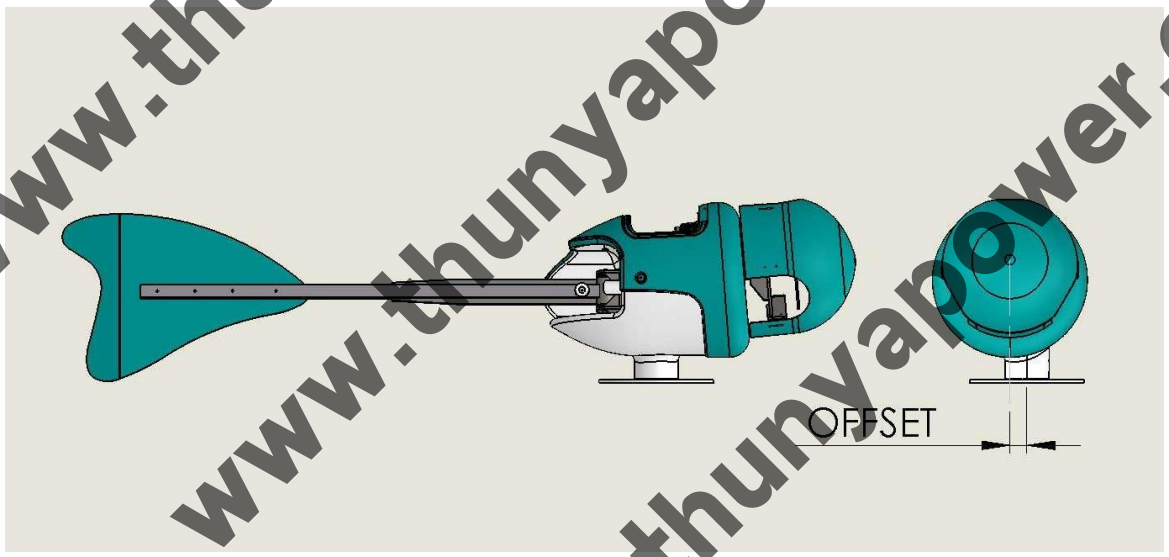
[Table 2-2]



[Fig. 2-2]

3. Yaw System

Yaw system consists of body parts, slip ring, flange and hub. The necessary characteristic of yaw system is to withstand and provide protections for stable operations during instantaneously changing wind velocity and directions and other environmental conditions. Large wind turbines with output limiting control by the blades and the pitch, the generator is protected from over-excitations of a heavy wind condition such as hurricanes. On the other hands small wind turbines need additional protection devices to prevent fault conditions and safety of the grid in which the small turbine is sensitive to small changes in the system. These output limiting methods are mostly from mechanical aspects of the system. This Yaw system has a side-furling system that moves tail, head and blades, parallel to the wind direction. The wind turbine system, the tail is located at the center of the blade-axis and the tail. It limits the output power more when the wind velocity is faster than 15m/s.

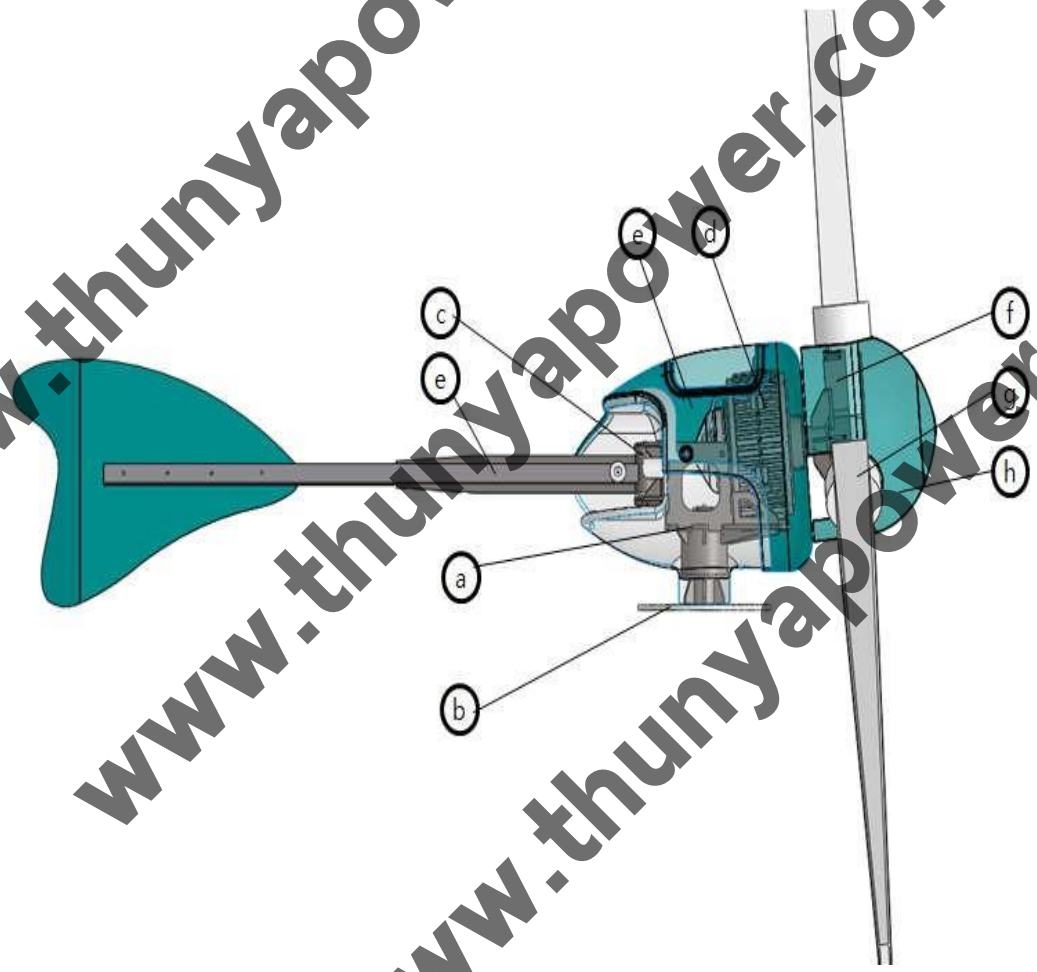


[Fig. 3-1]

3.1. Assembly

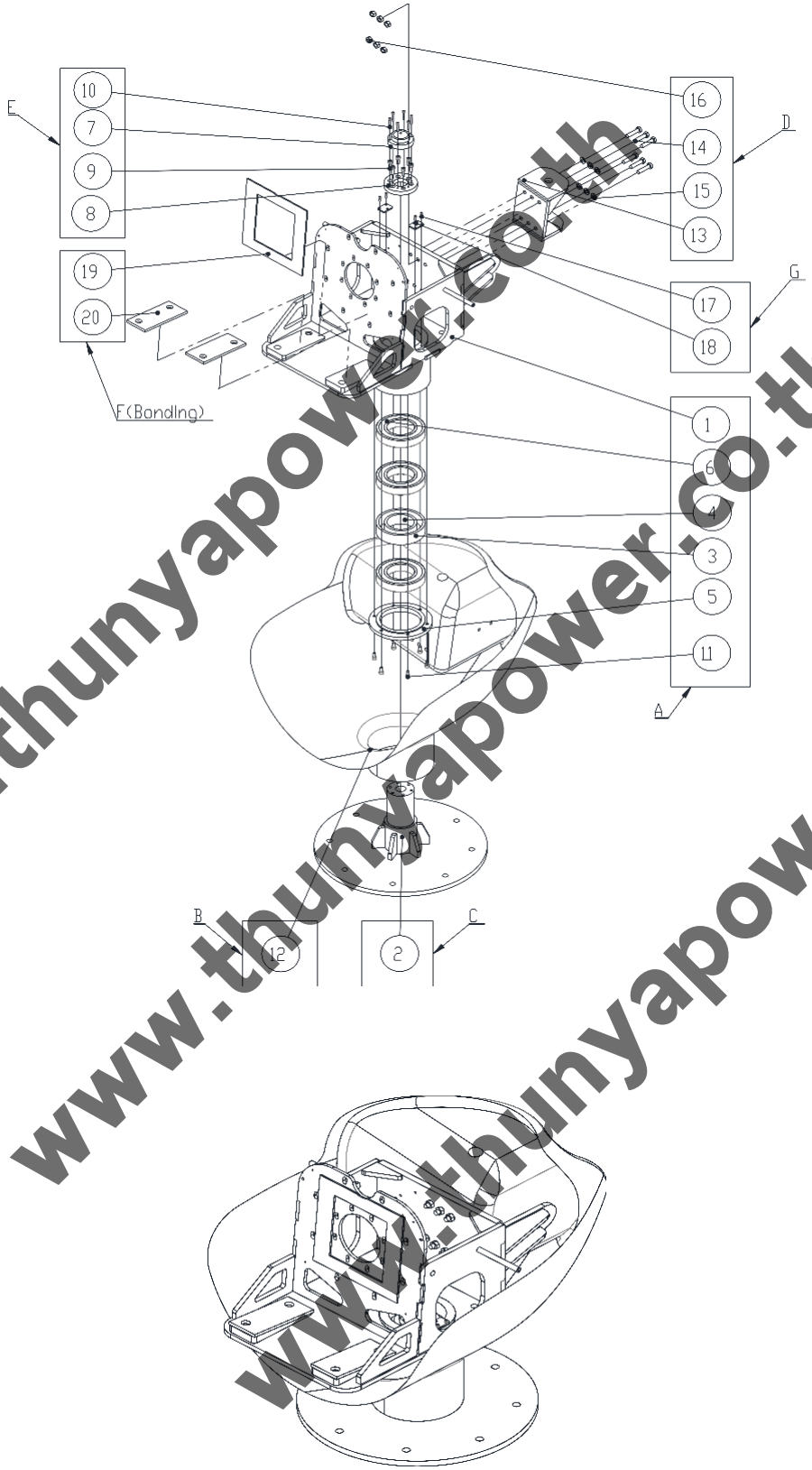
☞ **Key Point**

- ⓐ **Nacelle Frame**
- ⓑ **Yaw Flange**
- ⓒ **Pivot Bracket**
- ⓓ **Generator**
- ⓔ **Tail Vane & GFRP Upper Cover**
- ⓕ **Hub**
- ⓖ **Blade**
- ⓗ **Nosecone**



[Fig. 3-2]

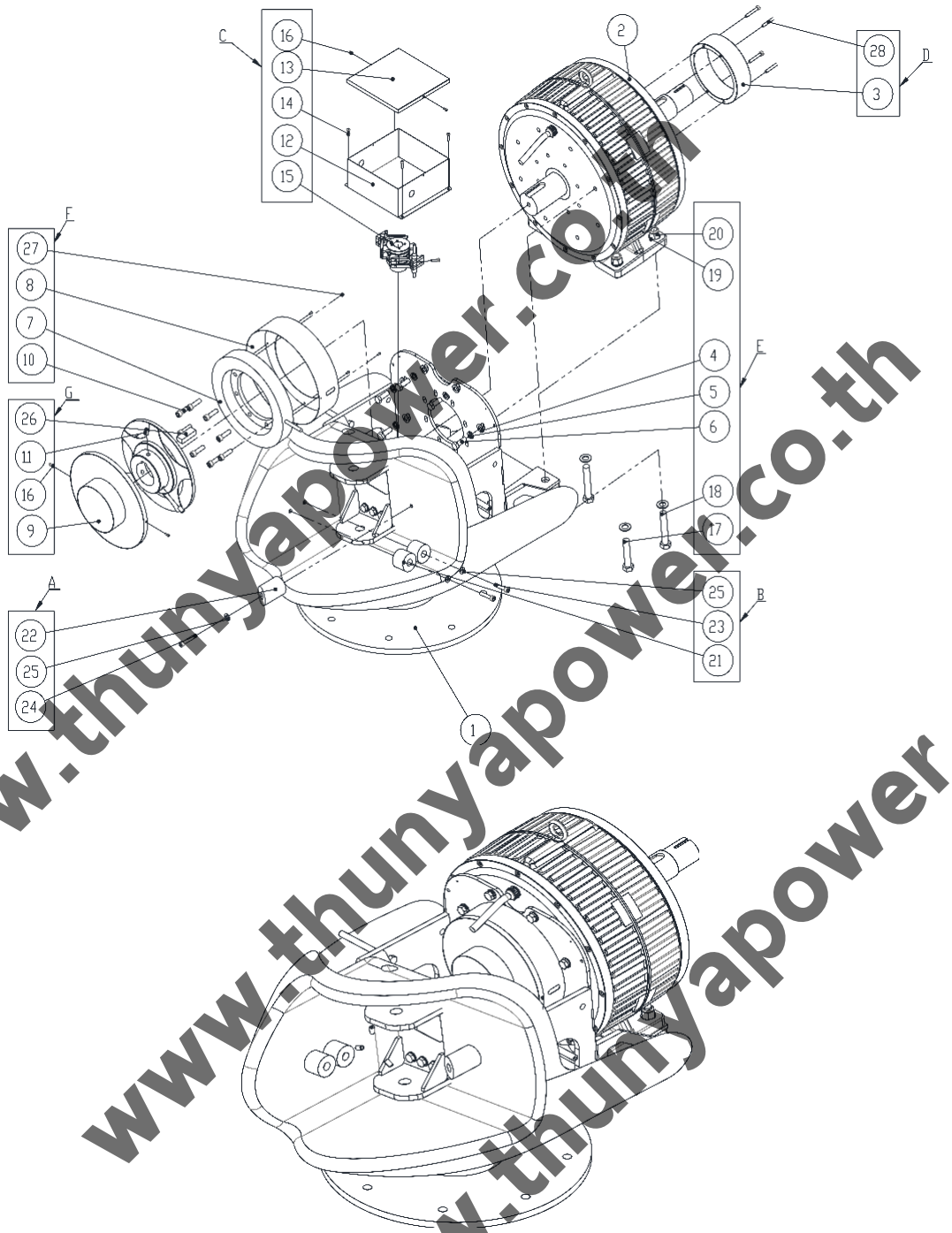
The main assembly procedure is shown below in Fig. 3-3.



[Fig. 3-3] Assembly for Nacelle Frame

[Table. 3-1] Component for Nacelle Frame

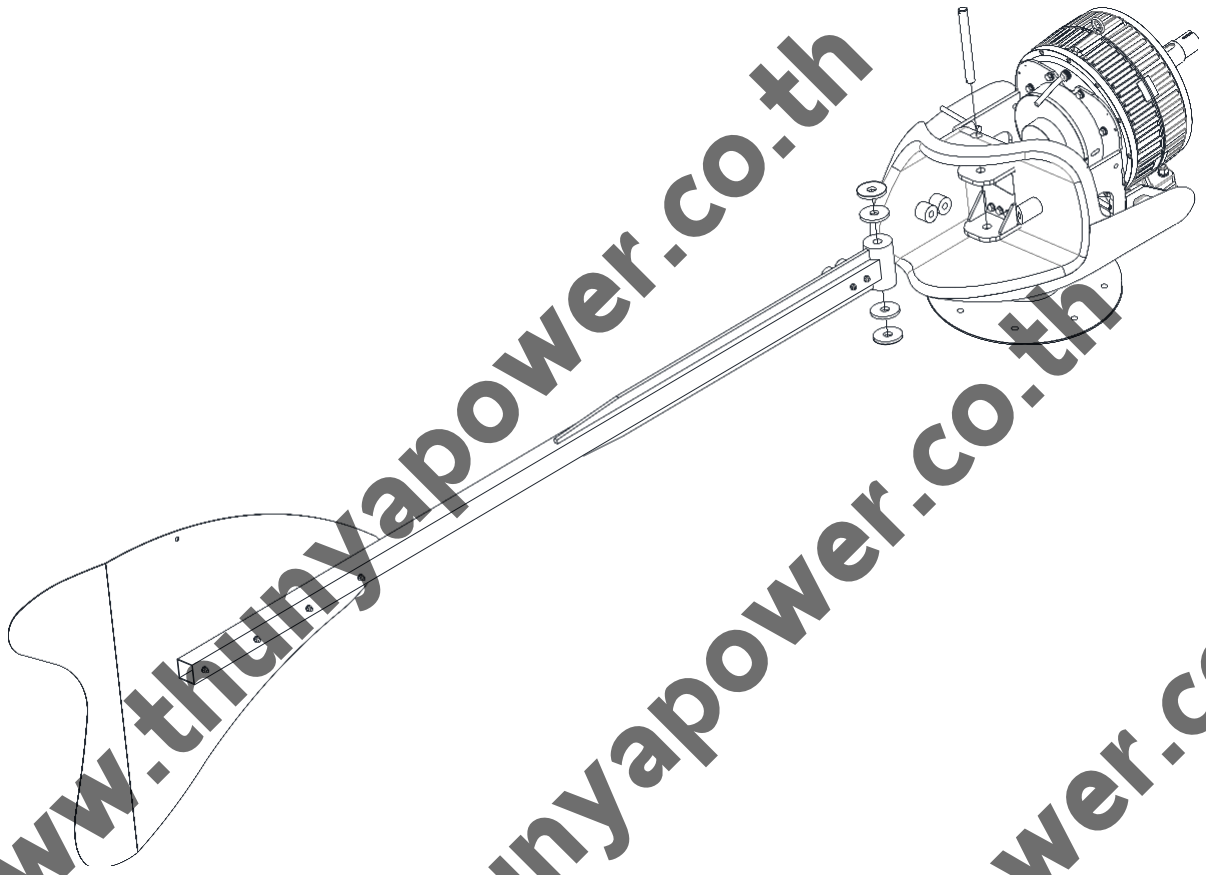
No	P/Name	P/No.	QTY
1	10kW Nacelle Frame ASSY	30400015	1
2	10kW Yaw Flange ASSY	30400038	1
3	Bearing Supt OTR	30400042	1
4	Bearing Supt INR	30400043	1
5	Yaw Bearing Holder	30400044	1
6	Yaw Bearing (6221ZZ)	22600010	3
7	slip ring supt (PE)	30400046	1
8	slip ring supt (steel)	30400045	1
9	Wrench Bolt (M10x25)	50300109	6
10	Wrench Bolt (M6x35)	50300103	6
11	Wrench Bolt (M10x20)	50300110	6
12	10kW FRP LWR Cover	40500005	1
13	Pivot SUPT	30400062	1
14	Hex Bolt (M14x60)	50300137	6
15	Flat Washer (M14)	50300145	6
16	Hex Nut (M14)	50300138	6
17	Wrench Bolt (M6x15)	50300104	4
18	Slip RING STOPPER BRKT	30400034	2
19	Rubber Pad - Generator RR	30400035	1
20	Rubber Pad - Generator SUPT	30400036	2



[Fig. 3-4] Assembly for Generator (top) and E-Brake (bottom)

[Table. 3-2] Component for Generator and E-Brake

No.	P/Name	P/No.	QTY
1	10kW Nacelle Frame ASSY		1
2	10kw Generator ASSY	30400001	1
3	Nacelle cover SUPT RING	30400047	1
4	Flat Washer (M14)	50300145	8
5	Spring Washer (M14)	50300121	8
6	Hex Bolt (M14x40)	50300138	8
7	E-BRAKE-70kgm	30400049	1
8	E-BRK LWR Cover	30400057	1
9	E-BRK UPR Cover	30400050	1
10	Wrench Bolt (M12x40)	50300108	8
11	Set Screw (M12x20)	50300122	3
12	Slip Ring cover - 1	30400080	1
13	Slip Ring cover - 2	30400081	1
14	Sems Bolt (M6x10)	50300104	4
15	Slip Ring	22700002	1
16	Wrench Bolt (M4x10)	50300103	4
17	Hex Bolt (M20x100)	50300135	2
18	Hex Bolt (M20x120)	50300135	2
19	Flat Washer (M20)	50300144	8
20	Nylon Nut (M20)	50300125	4
21	stopper pad no.1	30400024	2
22	stopper pad no.2	30400032	1
23	Wrench Bolt (M10x50)	50300111	2
24	Wrench Bolt (M10x60)	50300114	1
25	Flat Washer (M10)	50300146	3
26	Key (24x12x63)	30300089	1
27	Round Headed Wrench Bolt (M4x10)	50300123	4
28	Wrench Bolt (M8x50)	50300100	4
29	Wrench Bolt (M6x20)	50300104	1



[Fig. 3-5] Assembly for Tail Fin

a. Nacelle Frame

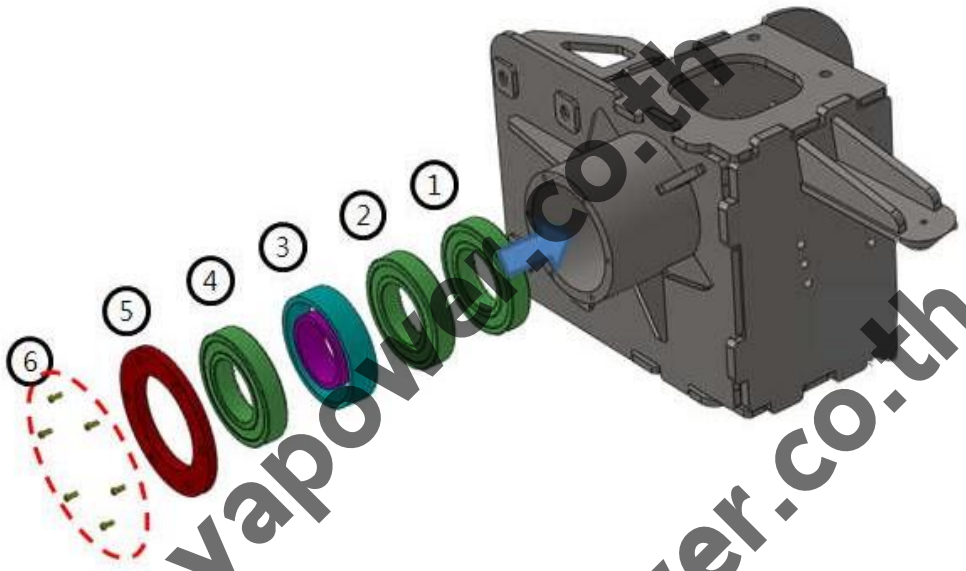
Nacelle frame is welded and constructed a piece as shown in Fig. 3-6. There are holes to mount the generator, the electronic brake and the pivot tail.

At first, assemble yawing bearings in the sequence according to the assembly procedures and Fig. 3-6 below.

- Sequence of yaw bearing assembly procedures

① Insert the Yaw Bearing(6221ZZC3, 2 each)
② Insert the Yaw Bearing(6221ZZC3)
③ Insert the Yaw Bearing SUPT Inner/Outer
④ Insert the Yaw Bearing(6221ZZC3)
⑤ Insert the Yaw Bearing Cover
⑥ Assemble M10 Bolts to mount the Yaw Bearing cover

[Fig. 3-6]



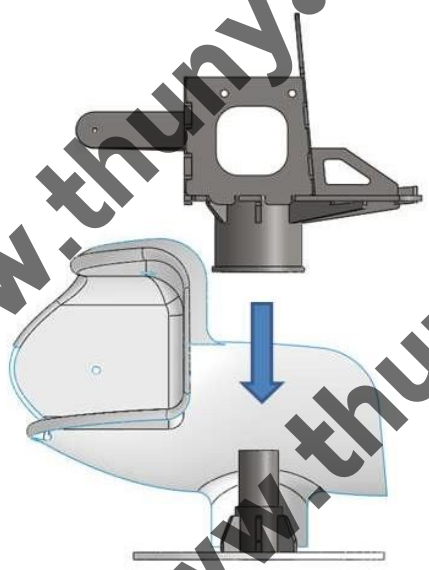
[Fig. 3-7]

b. Yaw Flange

Yaw Flange is welded and constructed with the yaw shaft which has been built with reinforced ribs as shown in Fig. 3-8.

Before assembling the yaw flange, place the Lower GFRP Cover on the yaw shaft shown in Fig. 3-9. Use the hoise crane with double eye sling-belt to lift the Nacelle body and place it on the Yaw bearing as Fig. 3-9.

[Fig. 3-8]



[Fig. 3-9]

[Fig. 3-10]

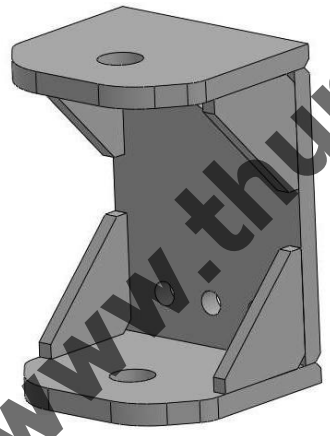
c. Pivot Bracket

Pivot bracket is a component to assemble the tail pivot(FIG. 3-11). It's a component to protect system through side furling function of tail vane In strong wind. The assembly procedures is provided in Fig. 3-12 and below.

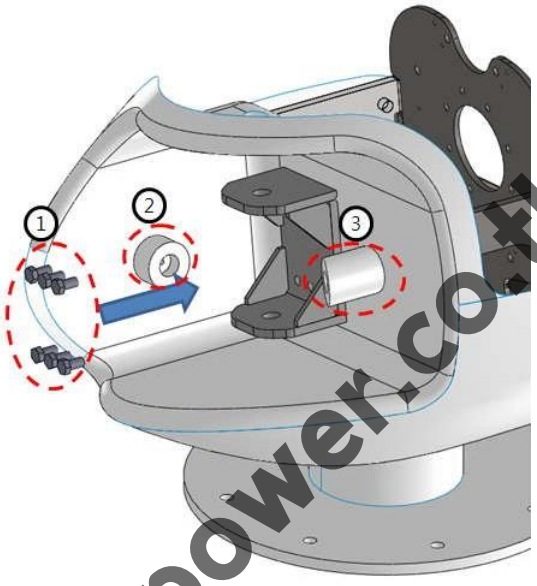
- Sequence of Pivot Bracket Assembly Procedures

① Assemble pivot bracket and bolts (M16)

②, ③ Assemble the Stopper Pads (Urethane shock absorber)



[Fig. 3-11]



[Fig. 3-12]

d. Generator

At first, it is important to understand the purpose of the holes and tabs on the generator surface to assemble the Nacelle frame and the generator.

- Descriptions of the hole and tab locations (Fig. 3-13)

① Upper GFRP cover locking ring (4 places)
② E-Brake (8 places)
③ Generator to the Nacelle frame(8 places)
④ Generator to the Nacelle frame(4 places)

[Fig. 3-13]

In the back of the generator E-Brake is equipped to protect the generator system. Assembly descriptions are following below.

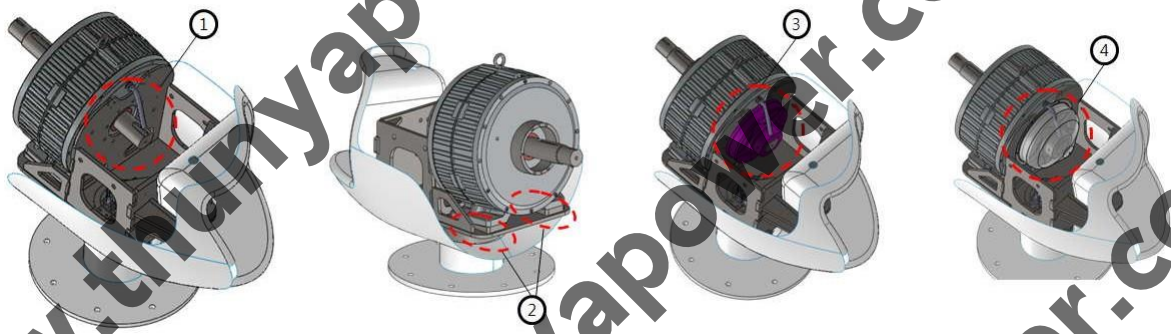
- Sequence of Nacelle frame assembly (Generator and E-Brake)

① Assemble the generator cover and the Nacelle frame on the back (M14 Bolt, 8 each)

② Assemble the bottom of the generator and the Nacelle frame (M20 Bolt, 4 each)

③ Install E-Brake (M12 Bolt, 8 each)

④ Install E-Brake cover

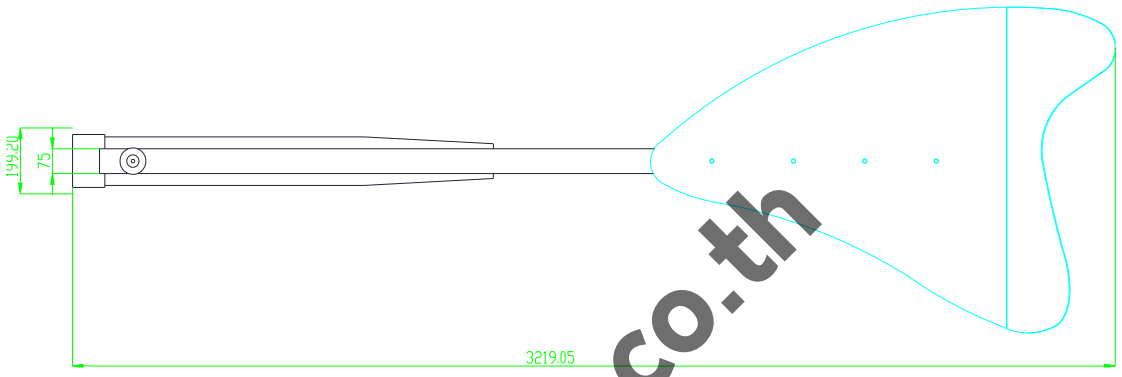


[Fig. 3-14]

e. Tail Vane & GFRP Upper Cover

Tail part is designed to furl the system against the gust wind. It is made of rubber and urethane composite for the maximum shock absorption and protection.

The pivot tail with several plastic-composite material rings inserted, plays a rol as a surface bearing. It requires two rings on each side of upper and lower surface which must be assembled very carefully.



[Fig. 3-15]

When the upper cover is assembled, disassemble the upper cover parts described below (Refer to Fig. 3-16). After disassembled the upper cover parts, install the pivot tail and the plastic rings. Then insert pivot pins to hold them.

- Procedures of the upper cover disassembly

① Remove M8 bolts and the retainer cover
② Remove M8 bolts (for fixing the upper cover)
③ Remove the top of the upper cover

[Fig. 3-16]

The procedures of pivot pin are described below. (Refer to Fig. 3-17)

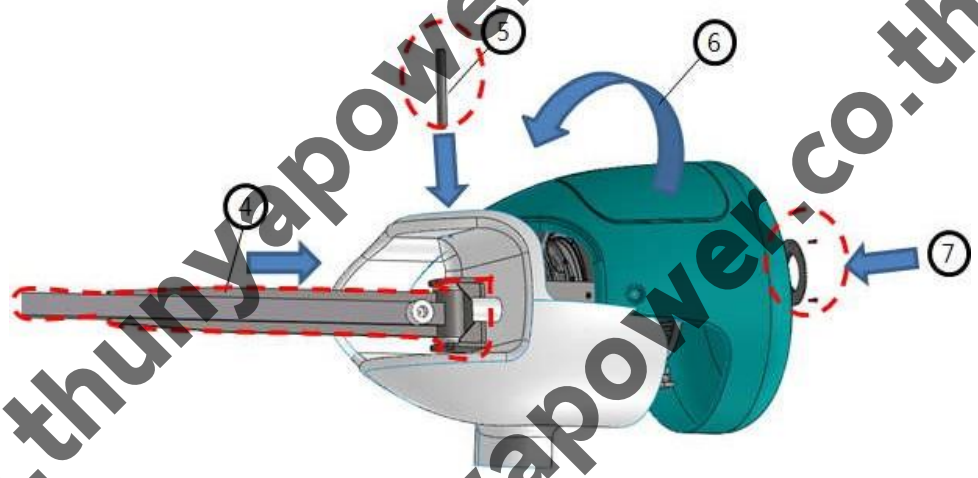
- Procedures of the upper cover assembly

④ Insert the tail pivot with flat washer (Refer to Fig. 3-18)

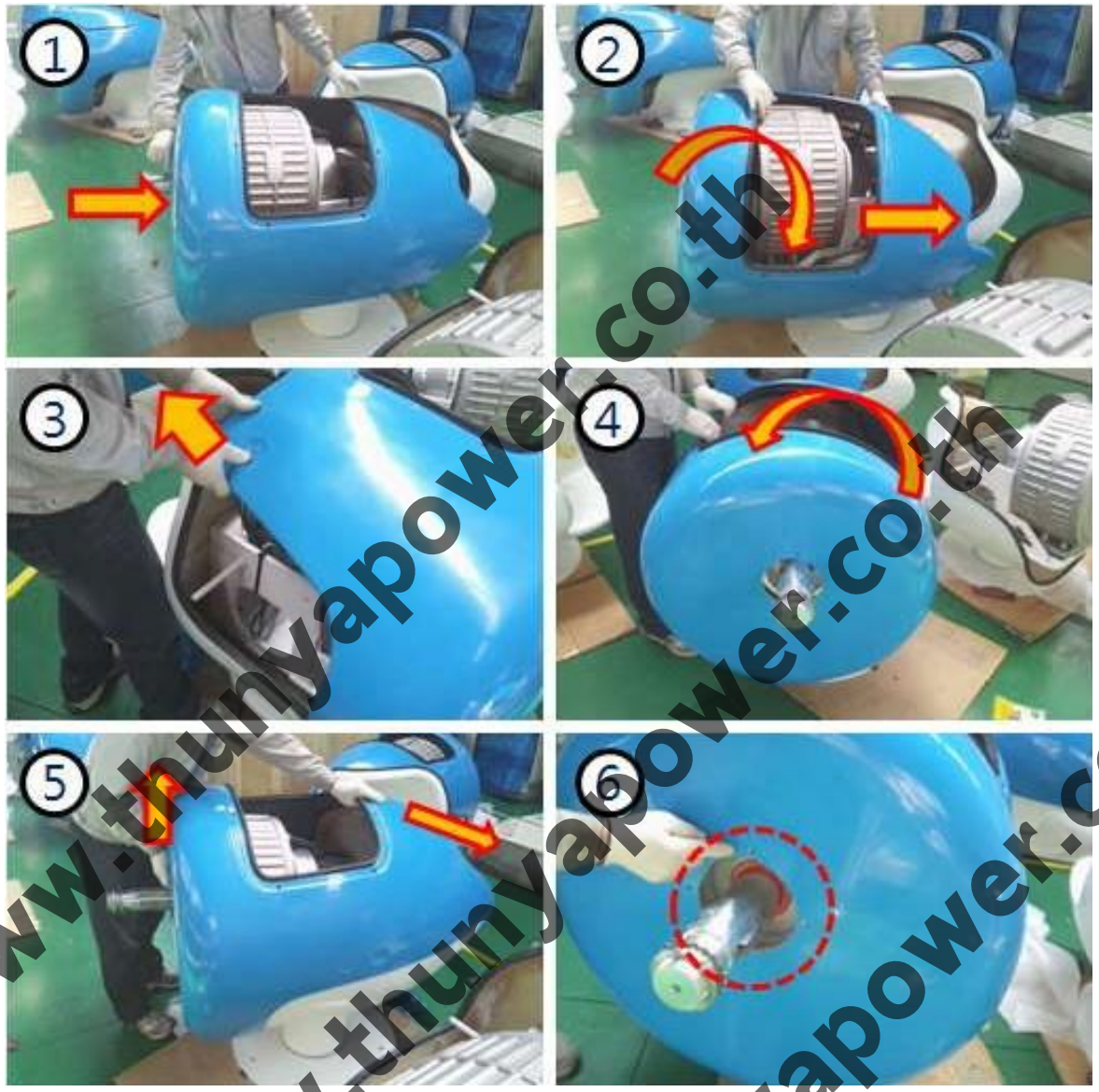
⑤ Insert the pivot pin

⑥ Assemble the upper cover

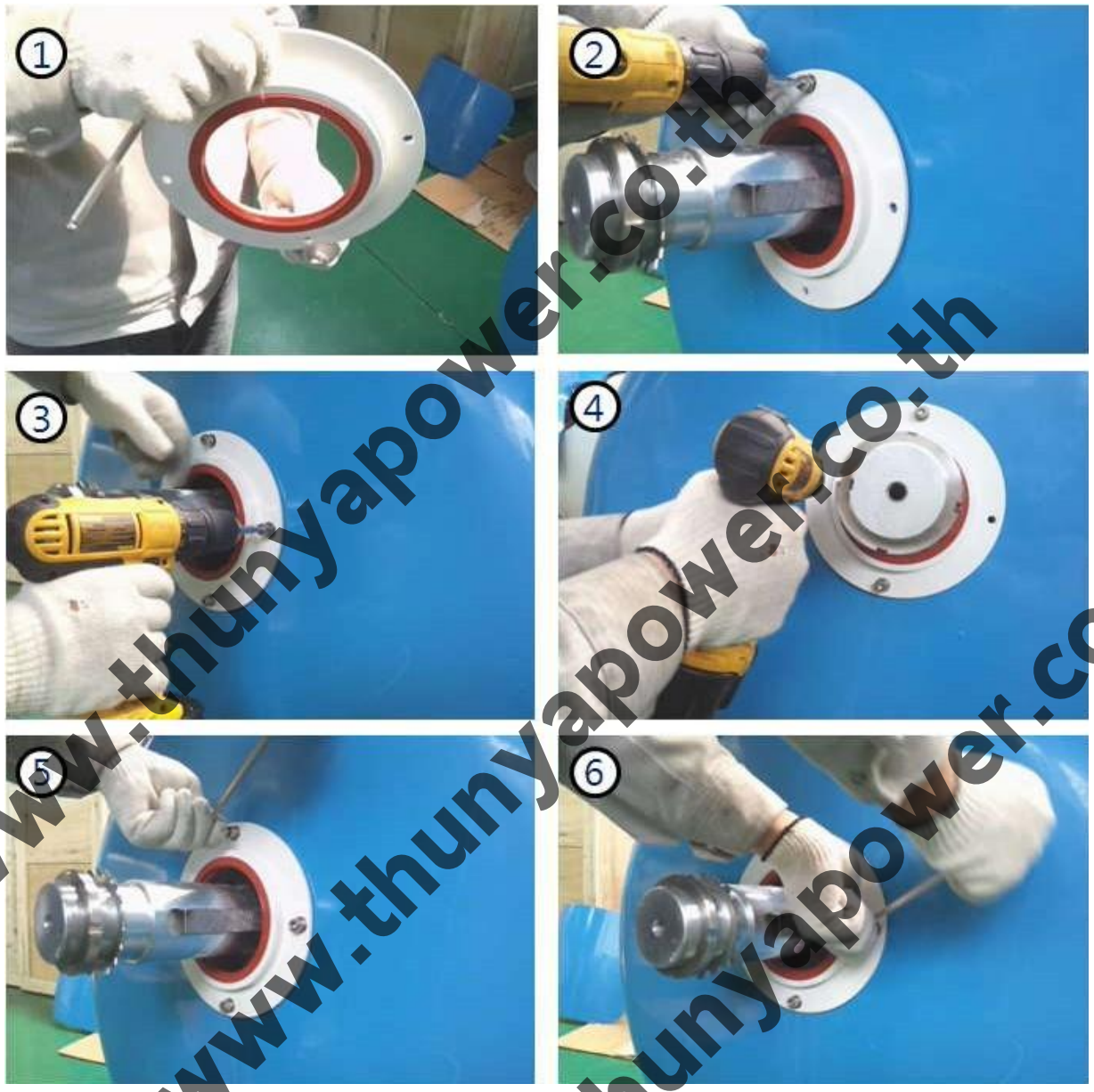
⑦ Assemble the retainer cover and upper cover using M8 bolts (Refer to Fig. 3-19)



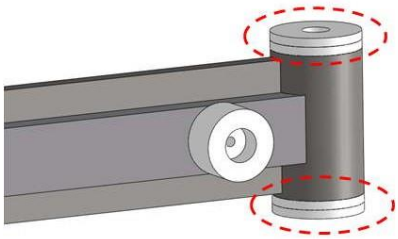
[Fig. 3-17]



[Fig. 3-18] Procedures of the upper cover assembly

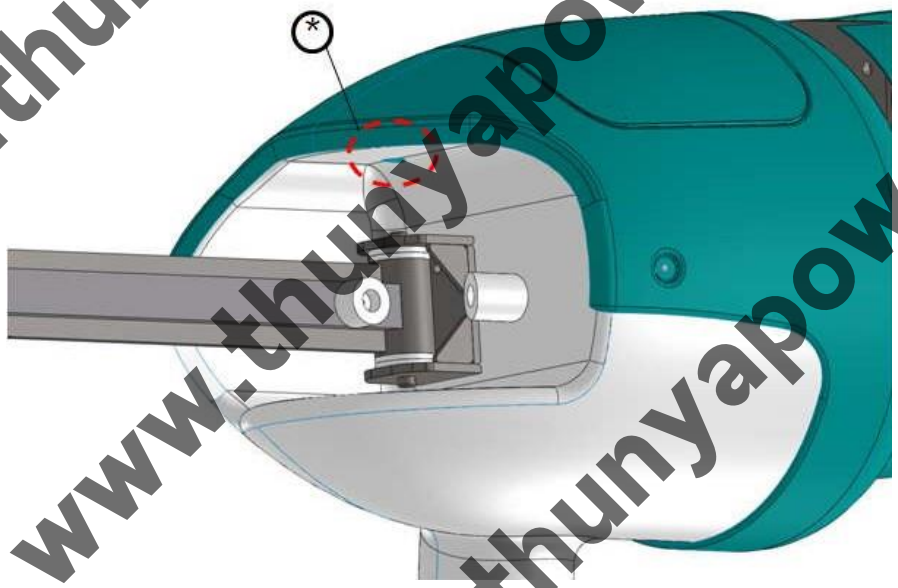


[Fig. 3-19] Procedures of the retainer cover assembly



[Fig. 3-20]

After the pivot pin and the pivot tail assembly, fix the pivot pin using bolts or hitch pin (refer to Fig. 3-22) so they will not come out of the place. The picture of the completed assembly is shown in Fig. 3-21. The hole(*) for the pivot pin is covered with a plastic cap for waterproofing.

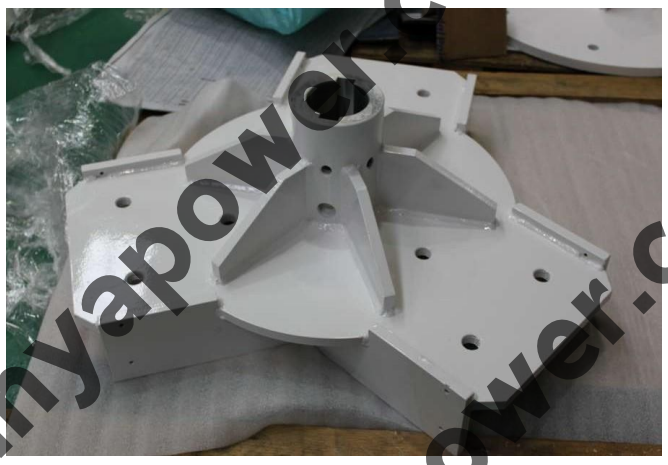


[Fig. 3-21]

[Fig. 3-22] Procedures of the tail pin assembly

f. Hub

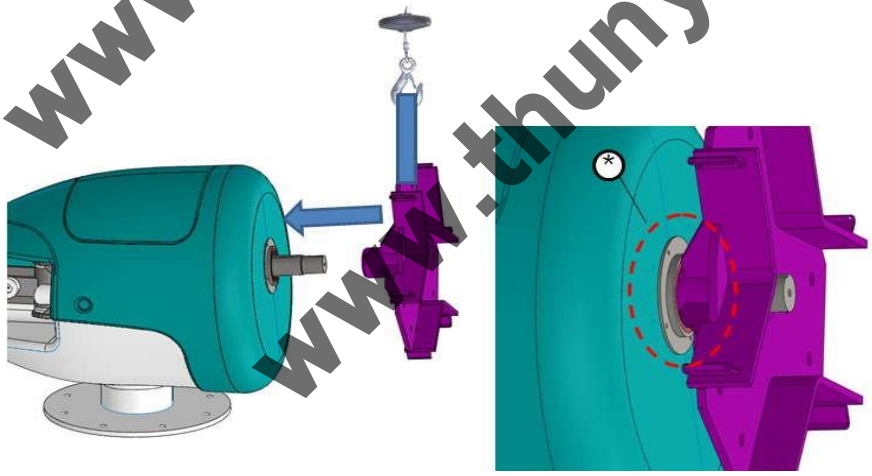
Hub is a part of the mounting support to deliver mechanical force from the blades to generator. In order to mount and hold the blades, it is connected with three M24 bolts on each blade. After assembling the hub on the generator shaft, the hub should be mounted with 4 set screws. Lastly, assemble the lock nut (loose stoper).



[Fig. 3-23]

- Sequence of the hub assembly

① Assemble generator shaft key (24x16x105, 2 each)
② Insert the hub into the generator shaft using a hoist crane
③ Insert the hub shaft into the retainer (*)
④ Install the set screw
⑤ Assemble the lock nut and lock washer with M70 bolts.

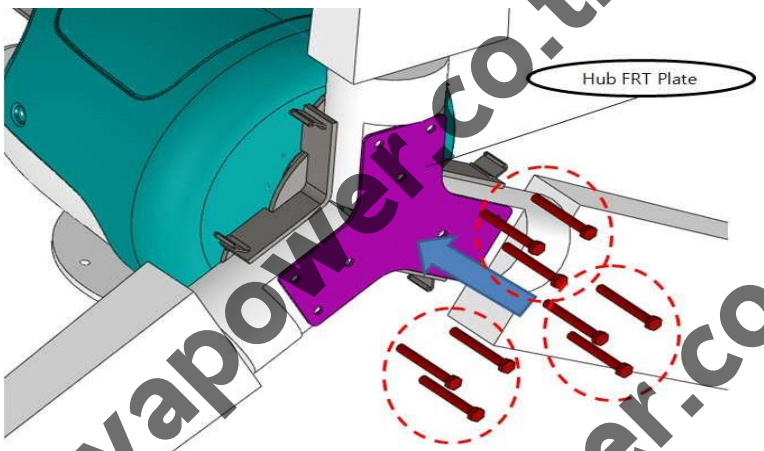


[Fig. 3-24]

[Fig. 3-25] Procedures of the hub assembly

g. Blade

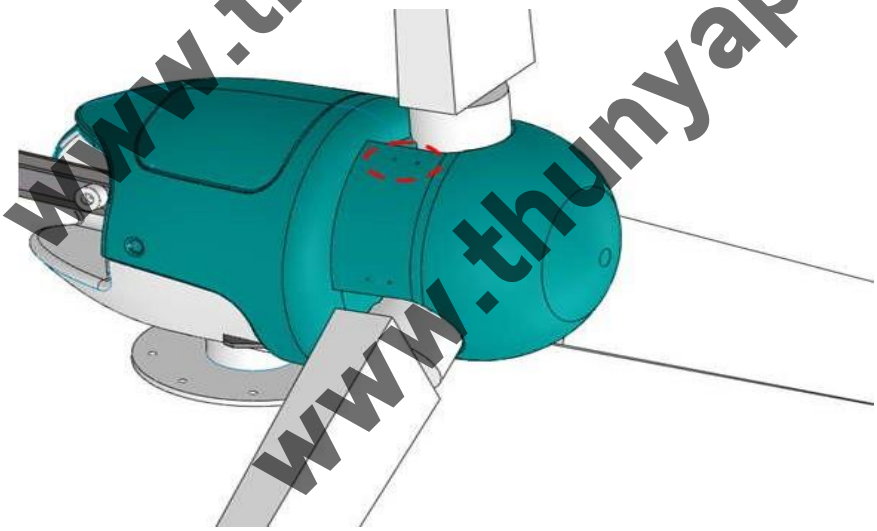
Assemble blades refering to Fig. 3-26. To mount the blade to the hub, use M24 bolts (3 on each blade) after attach the Hub FRT Plate to the blade. Make sure M24 nuts are tightly secured at the back of the hub.



[Fig. 3-26]

h. Nosecone

Assemble Nosecone as shown in FIG. 3-27. It is mounted with M6 bolts with a flat washer on each bolt.

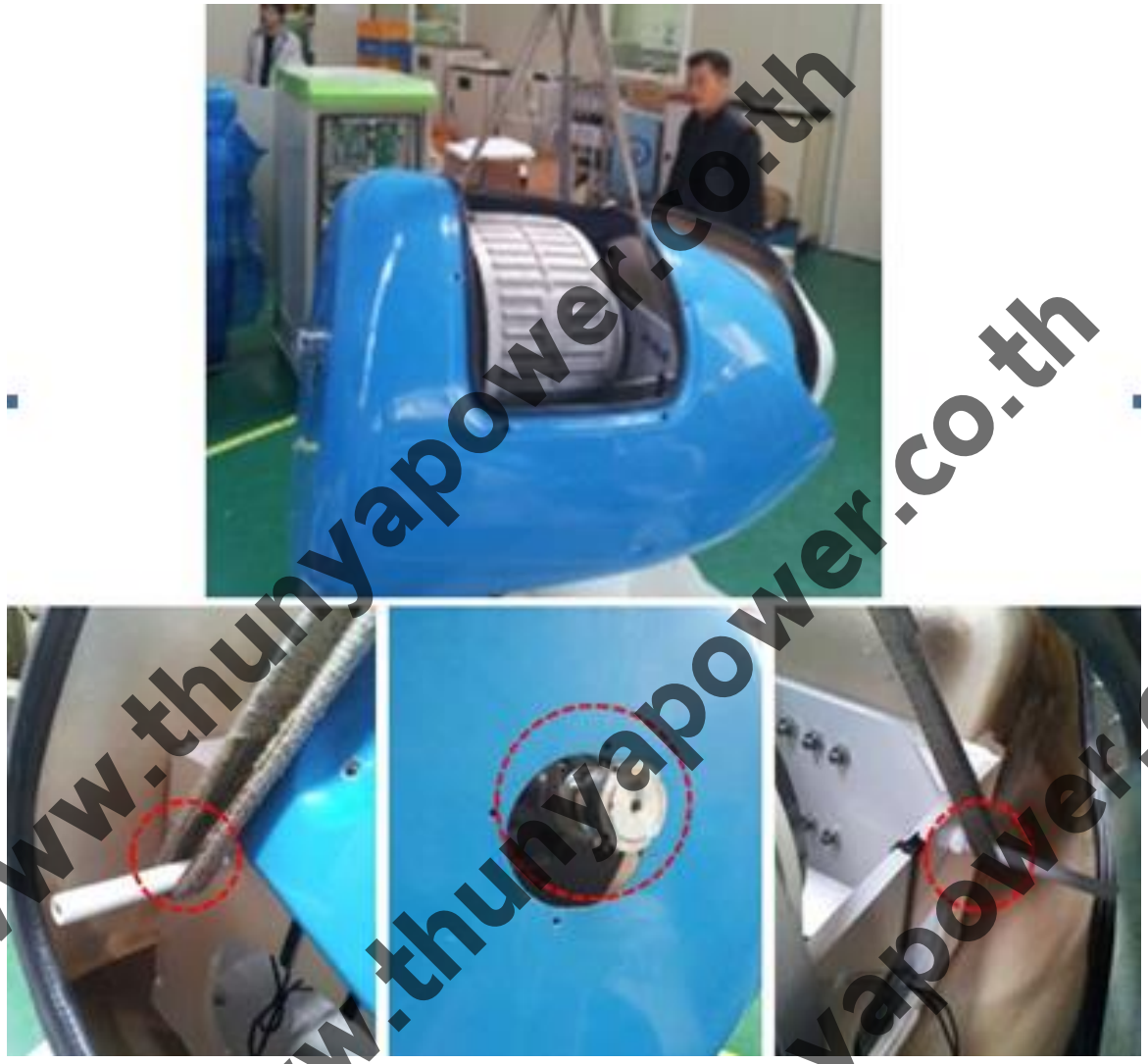


[Fig. 3-27]

4. Unpacking Procedure

a. Unpacking the Box of the 10kW Wind Turbine

b. How to connect belt using a crane for Nacelle



5. Inverter System (Power Conversion Devices)

5.1 Electrical Specifications

Input	Maximum Current	50 A
	Rated Voltage	400 Vdc (Programmable range from 175Vdc to 800 Vdc)
	Source Type	Wind
Output	Rated output	10.0 kW
	Maximum Output Current	30 A
	Rated Voltage	Grid voltage @ 380 Vac, (Line Voltage)
	Phase Type	Three Phase
	Power Factor	More than 0.95
	THD	Below 5 %
	Control Method	PWM
	Efficiency	More than 94 %
protection function	Stand-alone Running Protection	Within 0.5 second response time
	Overload	Within 110 % of output
	Inverter Error Detection	Input over voltage, input over current, output over load, over heat, leakage current
	Grid Error Detection	Over voltage, under voltage, frequency distortion, islanding

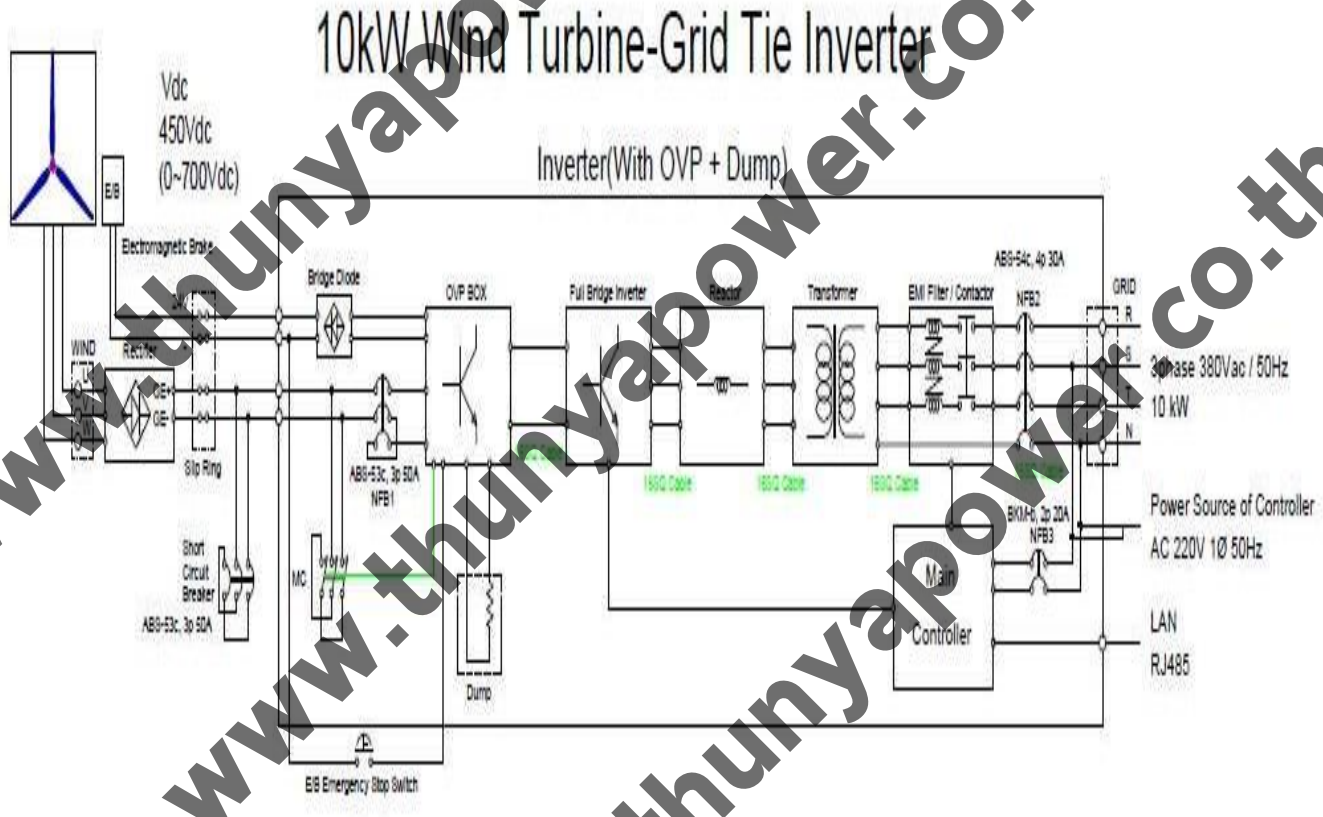
5.2 Mechanical Specifications

Structure	Cooling System	Naturally inspired, air-cooled
	Protect Level	IP 22/ NEMA 3R
	Sound Noise	Below 55 dB
	Dimension	560 x 784 x 1327 [mm]
	Weight	100 kg
Operating Environment	Operating Temperature	-10 ℃ ~ 50 ℃
	Storage Temperature	-40 ℃ ~ 80 ℃
	Operating Humidity	Below RH 90 % (without condensation)
	Environment	non-flammable gases, cauterant gases
	Altitude	Below 1,000 m
	Vibration	Below 0.5 G (4.9 ㎨)

* GE+, GE-, EB+, EB-: Line labeling

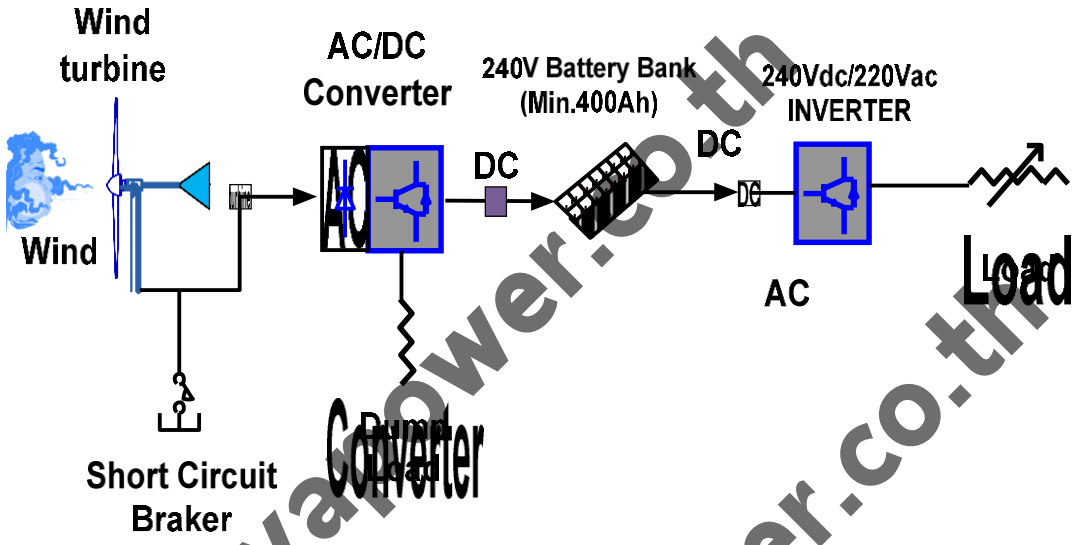
◆ Caution ◆

1. Be careful when connect the wind turbine output and inverter input
2. If wires are connected incorrectly, the turbine and the inverter systems can malfunction and damage both mechanical and electrical systems.

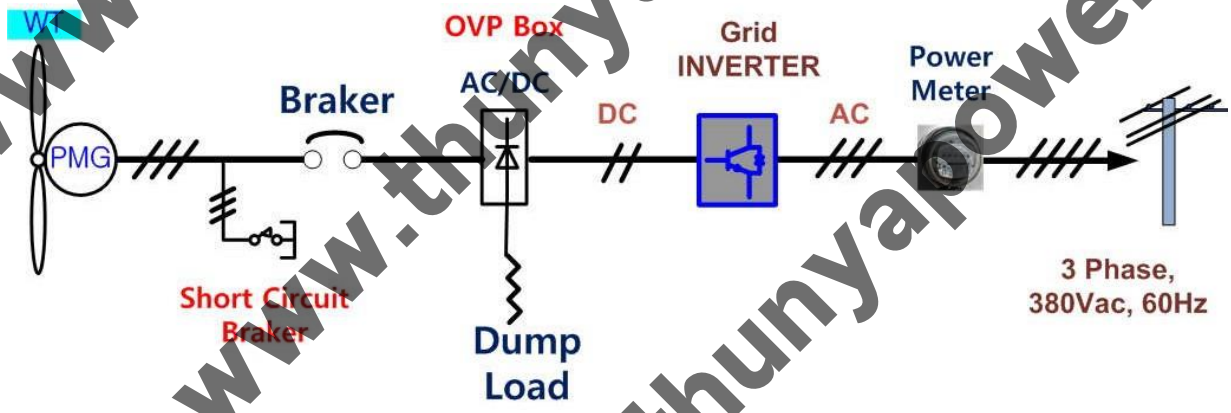


3 Guideline for Generator Operations

1. Operating the wind turbine generator and the emergency stop



<Stand - Alone>



<Grid-Tied>

[Fig. 3-1]

1.1 Operation

Manual stop breaker location: access hole under the tower or the built-in inverter control cabin.

- ☞ First, turn ON the Grid-tied switch (NFB Braker shown in FIG. 5-1) and check the inverter status.
- ☞ Turn ON turbine and OFF the Short Circuit Braker.
- ☞ Observe the rotation of the blades. If vibration and noise increase while rotor is rotating, stop the turbine with the emergency circuit breaker.

1.2 Stop

During emergency, tower vibration and noise, maintenance situations, switch ON the emergency stop breaker to stop the turbine.

- ☞ Check the generator and the emergency stop circuit breakers OFF to avoid excessive force applied on the blade during the high speed rotation.
- ☞ Turn OFF the short circuit braker to stop rotor rotation.
- ☞ After stopping the wind turbine, turn OFF the grid-tied or/and inverter to stop the complete operation.

4 Maintenance or Inspection

1. Maintenance and inspection of wind turbine system (10kW)

Part(s)	Inspection Tips	Actions
Blade	Check mounting bolts and nuts.	Tighten bolts and nuts firmly, and use a lock-tight glue to prevent getting loosened by vibrations.
	Inspect visually each blade part if there is any damage. (If generator has been shorted or stopped)	If there are scratches, cracks, etc. take appropriate action with tapes only for the blade use. If broken, replace the blade immediately.
Generator	Check the noise level	Check the hub connection, its mounting parts and generator shaft. If there is any problem found apply a lubricant to reduce the friction. If the noise consistently increasing, stop the operation and contact the dealer for the repair/maintenance service.
	Check generator rotor rotations (blade rotations)	If generator has been faulted or/and shorted, check inside of generator rotor and stator if they rotate smoothly. If the problem continues, contact the dealer for the repair/maintenance service.
	Check the generating power	Check the open circuit voltage. If there is not any problem found, check the inverter. * Refer to inverter inspection section.
Yawing	Check each part of Tower and yawing joints (bolt and nuts).	Tighten bolts & nuts firmly, and use lock-tight glue to prevent loosening caused by vibration.
	Inspect visually if there is any damage on the part of yawing.	Replace damaged parts immediately.
	Check the vibration of yawing.	Check yawing, tower, junction and rubber seal. If there is any severe wear or damage, replace it with a new part.
Tail	Check the furling tail.	Check tightness of nuts on furling parts. If they are too tightly secured, the tail cannot furl freely. Apply lubricants to furl smoothly.
	Inspect visually if there is any damage on the part of tail.	Replace the damaged part immediately.
Tower	Check each part of the joints (bolt and nuts).	Tighten bolts & nuts firmly, and use lock-tight glue to prevent loosening caused by vibration.
	Check the visible damage.	Use repair tools or kits if there are physical shape damage. If the damage is severe, get assistance from professional welder to repair the part.
	Check corrosion caused by water, temperature, humidity, etc.	If lightly rusted, peel the rusted parts with a scrapper or a sand paper. Apply primer and paint the rusted part. If the rust is severe, get assistance from professional welder to cut the rusted portion and point-weld to restore.
	Check status of guide wire	If loose guide wire tighten more turnbuckles and check the status.

Part(s)	Error Code	Cause	Action
Inverter	1	Communication error inside the inverter	Contact the dealer/distributor for the service.
	2	Communication error inside the inverter	Contact the dealer/distributor for the service.
	7	DC link down during the operation	Check the inverter stopping voltage and the source voltage. Restart the inverter when the input voltage has been restored.
	10	Temperature overheating	Check cooling condition and its operation after turing OFF then restarted. If the inverter does not restart, contact the dealer/distributor for the service.
	11	Temperature sensor error	Contact the dealer/distributor for the service.
	12	Temperature switch in stack (Temp. SW. Open)	Check the connector terminals and the ventilation equipment. Reactivate the inverter after it cools down awhile.
	13	Fuse switch in DC link (Fuse Blown Up)	Replace the fuse on the stack of the inverter. (Make sure turn off the inverter before replacing the fuse. Reactivate the inverter after)
	14	Temperature switch in reactor	Check the connector terminals and the ventilation equipment. Reactivate the inverter after it cools down awhile.
	15	Temperature switch in transformer	Check the connector terminals and the ventilation equipment. Reactivate the inverter after it cools down awhile.
	20, 21	Over-voltage on input	Check the status of input voltage and power.
	22	Over-current on input	Check the status of input current and power.
	23	Over-current on Source	Check the generator voltage and current. Reactivate the inverter if the generator runs normally.
	30	IGBT Fault on U-phase	1) Check the IGBT drive if it is burned out. 2) Error message is consistent. In a case of either 1) or 2), replace the IGBT module.
	31	IGBT Fault on V-phase	The same as 30.
	32	IGBT Fault on W-phase	The same as 30.
	33	Over-current U-phase of the inverter	If faulted, clear the fault and re-operate. If shorted, restart the inverter.
	34	Over-current V-phase of the inverter	Same as 33.
	35	Over-current W-phase of the inverter	Same as 33.

Part(s)	Error Code	Cause	Action
Inverter	36	Over-current on inverter input on U, V and W	Check the current of the Inverter, the Grid, the stack. Reactivate if they are in the normal condition.
	37	Unbalance of the inverter output phase voltage (The output phase voltage unbalance between two of three phases (U,V,W) exceeds the normal level)	Check the current and the voltage of the inverter and the grid, the wiring condition and the stack. Reactivate if they are in the normal condition.
	38	Unbalance of the inverter output phase current (The output phase current unbalance between two of three phases (U,V,W) exceeds the normal level)	Check the current and the voltage on the inverter and the grid. Reactivate if they are in the normal condition.
	39	Frequency mismatch between inverter and grid	Check inverter frequency setting if it is the same as the grid frequency.
	40	Inverter switching failure (Failure to generate output voltage)	Check the wiring, the IGBT module and the voltage of the inverter and the grid. Reactivate if they are in the normal condition.
	41, 42	Grid frequency error 41 = Under-frequency 42 = Over-frequency	Check the condition of the grid frequency whether it exceeds or below the accepted limit.
	43, 44, 45	Over-current on grid 43 = R-phase 44 = S-phase 45 = T-phase	If faulted, clear the fault and re-operate. If shorted, restart the inverter.
	46	Grid voltage error	Check the condition of the grid frequency whether it exceeds or below the accepted limit.
	47	Over-voltage on grid	Check the voltage on the grid and the power of the offset menu in the HMI.
	57	Leakage Current (Ground Fault)	The leakage current exceeded the limit. Repair the faulted part in the inverter on the load side and reactivate the inverter. If the error is consistent, contact the dealer/distributor for the service.
	58	Arc (current) Fault (Ground Fault)	Same as 57.
	63	Anti-islanding	Check status of the grid.

Part(s)	Error Code	Cause	Action
Inverter	64	Frequency setting error	Check inverter frequency setting if it is the same as the grid frequency. It may be caused by the frequency oscillation from the power grid by the frequency distortion.
	90, 91	PLL error on the grid 90 = Under-freq. of PLL 91 = Over-freq. of PLL	Check the harmonic frequency of the grid, and reduce harmonic distortions of grid voltage and current.
	95	IMC error [fault]	
	96	Source breaker error (DC-Link Break Off)	Turn on the DC-Link breaker.
	97	Grid breaker error (Grid_Breaker Off)	Turn on the grid breaker.

2. Maintenance cycles and procedures

Item	Cycle	Process	Note
1. Generator	2 year	- Check the hub and bearings if it functions normally.	
2. Blade & Hub	1 year	- Inspect the blades visually. (cracks, breakage, etc.) - Check the condition of hub and its connecting parts.	
3. Slip ring	2 year	- Check the status of cabling. - Conduct a function test of slip ring contacts.	
4. Yawing system	2 year	- Check the conditions of Yaw shaft and bearings.	
5. Tail Assembly	1 year	- Check the tail assembly and its operation. - Check the operating status of tail fin.	
6. Tower	often	- Check the tower mounting parts. - Check ground conditions. - Check the condition of the supporting wire and its tension.	

3. Lubrication cycles and type of lubricant to be used

Item	Cycle	Using	Note
Generator shaft bearing	1 year	Acanol KP2N-40	Germany Kugeelfisher
Yaw shaft bearing	2 year	Acanol KP2N-40	Germany Kugeelfisher
Tail Pivot bearing	1 year	Acanol KP2N-40	Germany Kugeelfisher