Birambye International
Wind Turbine Workshop

Ten Day Construction Workshop Manual

Location: Kigali Institute of Science and Technology
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Workshop Overview

The wind turbine workshop will train attendees to build from 'scratch' a 12 ft. diameter, 1.5 kW peak, 800 W average, permanent magnet axial flux wind generator (3 phase, 4 coils/series, star connected, 48 VDC), following the design of wind pioneer Hugh Piggott, and associated tilt-up tower[1]. The entire system will function as a stand-alone power system using battery power storage. The turbine consists of a central hand-wound stator sandwiched between two magnetic rotors (Figure 1). A 12 ft diameter, axial flux horizontal axis wind turbine and associated tilt-up tower will be constructed from 'scratch.' Students will work in three major areas for windmill construction:

1) Wood: blades, tail, molds/jigs

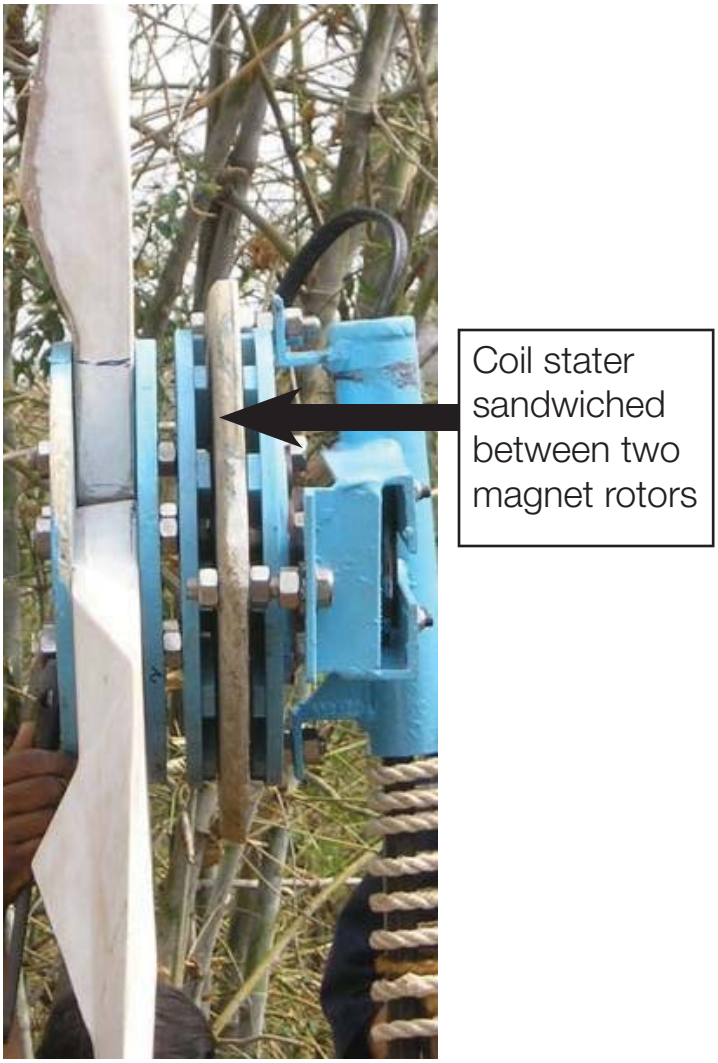
2) Metal: alternator mount, tail assembly, tower

3) Electrical: coil winding and casting, magnet rotors, transmission wire.

Ideally, the workshop would be held for 10 continuous days (strongly preferred). Otherwise, the workshop can be held over 2 weeks, Monday-Friday. Each day will typically begin with a 1 hr lecture, followed by construction for the remainder of the day. Blade carving, machining/welding, and electrical work will occur on every day. The course schedule and tools and facility requirements are detailed in the next pages, following a brief overview of some of the turbine parts.

Wind Turbine Parts

Figure 1: Axial Flux Wind Generator (left) and Wind Turbine Installation in India (right).



1 Swept Area = 113.1 ft2 = 10.5 m2

Figure 2: Magnet Rotor (left). Magnet wire used for coils in the stator cast in fiberglass jig (right).

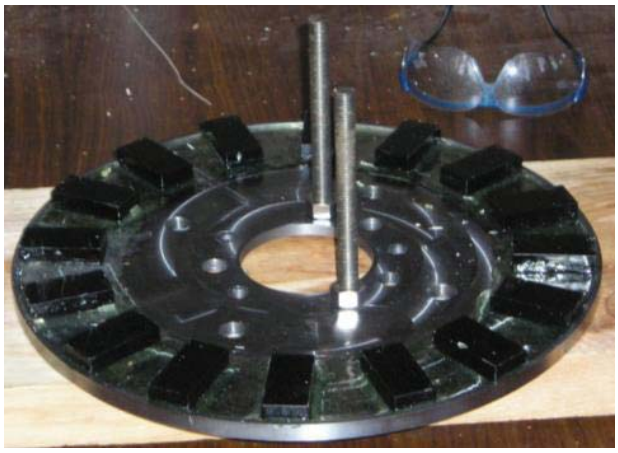


Figure 3: Completed tail frame assembly (left). Tail lugs on top two rows and Stator Mounts on bottom row (right).

Figure 4: Initial Steel Assembly. Yaw bearing tube (vertical pipe on left) mounted to horizontal alternator mount. Trailer hub shown. Jacking screws shown in lower right. (left). Wood Blades (left of right image), Circular mounting disc (middle of right image), Triangular blade mount (right of right image) Native weather resistant wood OR fiberglass blades (mold created at KIST from a blade carving). The 'triangle' and the circular disc to the right sandwich the blades together at the base, where it is mounted to the hub.

Class Schedule

DAY	DATE	LECTURE TOPIC	OBJECTIVES
DAY 1	14 JUNE	Construction Steps that make up the wind turbine and tower	. Introduction of wind turbine, tower construction & class project: Wind Turbine Construction Protocol . Safety hazards, warnings, first aid, clean-up instructions . Walk around and demonstration of how to use individual tools . Initial breaking into groups: electrical, machining, and wood working sections
DAY 2	15 JUNE	Wind Theory	. Blade carving – Step 1 . Design tail & cut out the tail, plywood blade triangles, and required molds/jigs . Machining – Hub mounting assembly . Electrical – Coil winding and jig preparation . Hub bearing preparation . Magnet disc and jig preparation
DAY 3	16 JUNE	Generator Governing: Furling tails	. Blade carving – Step 1-2 . Finish tail, blade triangles, mold/jigs . Machining – Hub assembly, tail boom assembly . Electrical – coil winding . Magnet placement
DAY 4	17 JUNE	Tower Basics & Tower Construction	. Blade carving Step 2-5 . Finish machining; begin and finish welding . Electrical – soldering and stator casting . Magnet rotor – casting . Test tower jig construction . Tower construction
DAY 5	18 JUNE	Electrical Theory: 3-phase generators	
DAY 6	21 JUNE	Windmill System Components; Stand-alone and Grid-connect Systems	
DAY 7	22 JUNE	Windmill Assembly	. Paint completed parts: blades, metal, tail, tower . Blade assembly and balancing
DAY 8	23 JUNE	Raising and Lowering Tilt-up Towers	. Assemble completed windmill on 7 ft high jig tower . Blade balancing and alignment . Test windmill output with a multimeter . Begin tower assembly
DAY 9	24 JUNE	Designing Stand-alone Battery Systems	. Complete tower assembly . Complete windmill assembly
DAY 10	25 JUNE	Class Synthesis and Future Construction Guidelines	. Loose Ends . Short Presentation by Student Groups on Various Wind Turbine Parts - Group 1: Wood - Group 2: Electrical - Group 3: Metal

Tools

KIST is requested to provide the majority of the tools below in order to minimize the tools that must be brought from the US by the instructor.

TOOL	INVENTORY CHECK FOR YES, BLANK FOR NEEDED	PROVIDED BY
METAL TOOLS		
Electric welder – arc or mig, mig preferred	_____	KIST
Welding mask	_____	KIST
Slag chipping hammer	_____	KIST
Table mounted vice	_____	KIST
Drill press	_____	KIST
+Handheld electric drill with ½" chuck	_____	MARK PITTERLE
+Drill bits	_____	MARK PITTERLE
+All purpose crosscut saws	_____	MARK PITTERLE
3/4" fine thread tap	_____	KIST
+hacksaw	_____	MARK PITTERLE
+cold chisel	_____	MARK PITTERLE
+hammer	_____	MARK PITTERLE
+center punch	_____	MARK PITTERLE
+files	_____	MARK PITTERLE
+tin snips	_____	MARK PITTERLE
+tape measure (3)	_____	MARK PITTERLE
set square (AKA carpenter's square)	_____	KIST
protractor	_____	KIST
+compass for drawing circles	_____	MARK PITTERLE
+spirit level	_____	MARK PITTERLE
calipers (1)	_____	KIST
ear protection	_____	KIST
safety glasses/goggles	_____	KIST
+face masks	_____	MARK PITTERLE
+screwdrivers	_____	MARK PITTERLE
+pliers	_____	MARK PITTERLE
+vice grips	_____	MARK PITTERLE
+adjustable wrenches	_____	MARK PITTERLE
+combination wrenches 1/4" – 1"	_____	MARK PITTERLE
+socket wrenches and ratchets ¼"-1"	_____	MARK PITTERLE

TOOL	INVENTORY CHECK FOR YES, BLANK FOR NEEDED	PROVIDED BY
WOOD TOOLS		
+C clamps	_____	MARK PITTERLE
+Hammer	_____	MARK PITTERLE
+Jig saw	_____	MARK PITTERLE
+Screwdrivers	_____	MARK PITTERLE
+Handsaw	_____	MARK PITTERLE
+Circular saw	_____	MARK PITTERLE
+steel ruler (3)	_____	MARK PITTERLE
Set square	_____	KIST
+Spirit level	_____	MARK PITTERLE
Calipers (1)	_____	KIST
PLASTICS & MISC. TOOLS		
Weighing scales	_____	KIST
+Safety glasses	_____	MARK PITTERLE
+Utility knife	_____	MARK PITTERLE
+Scissors	_____	MARK PITTERLE
+Wire strippers	_____	MARK PITTERLE
+Wire crimpers	_____	MARK PITTERLE
Soldering iron	_____	KIST
+Tape measure (1)	_____	MARK PITTERLE
+Spirit level	_____	MARK PITTERLE

Facility Requirements

Space is needed to accommodate three major tasks at one time: electrical work, machining/welding work, and wood work. Space must be able to tolerate wood dust and metal sparks. A drill press and table-mounted vice is required within these facilities. A total of 6 working tables are required:

- 3 – wood blade carving, must be a minimum of 6 ft long
- 2 – magnet work, miscellaneous ➔must be wood and requires drilling 2 holes through each table for magnet safety
- 1 – welding/metal work ➔must be metal and have a vice mounted on it