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Studies on Wind Energy applications during XVIII Indian Antarctic Expedition

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1.0 Introduction

Wind Energy is one of the most viable alternative energy source to produce Electricity. Different types of wind energy converters are available to harvest wind energy. The converter selection mainly depends on the type of application, environmental conditions energy requirement and other factors. Since Antarctica is one of the windiest continent, various scientific communities from different countries have attempted harvesting wind for production of heat and electricity in different parts of the Antarctic continent.

In line with Prof. U R Rao's expert committee recommendations on Antarctic Research, studies on wind energy conversion in the Indian station were initiated during the XVI expedition. With encouraging results reported, Department of Ocean Development encouraged NAL to pursue wind energy related work in Antarctica.

2.0 Background

National Aerospace Laboratories has been involved in the following wind energy related activities in Antarctica.

1. Resource estimation
2. Studies on energy consumption patterns
3. Infrastructure availability for installation of wind machines.

2.1 Resource Assessment

During XVI expedition, wind monitoring station was deployed and 3 level (28mts, 22mts and 12mts agl) monitoring was carried out using sophisticated microprocessor based instruments and sensors. An idea of energy requirements in the station was obtained.

While discussing the application of wind energy converters with former team members and leaders, it was found that there was a need to provide small generators for battery charging in location far away from the station. This was originally done by physically transporting charged batteries to the site. Sometimes

a small generator was also sent to the site. This type of power requirements can be adequately met with by deploying small wind power battery chargers.

2.2 Wind Machine Installation

During XVII Indian Antarctic expedition, two machines were deployed on an experimental basis. These two machines were installed to determine the effectiveness of such sites in remote areas and to study their performance. The aim was also to study the performance of the machines in the Antarctic environment. The machines performed reasonably well for some time and subsequently they developed various faults.

During the XVIII Expedition some of the problems were addressed and solutions provided.

3.0 Assignments during XVIII IASE

During our XVIII expedition, the following tasks were undertaken successfully.

1. Studying the wind powered battery charger deployed over the winter months for damage/performance.
2. Installation of new wind powered battery charger
3. Replacement of sintered bearings in the wind sensors and installation of new data retrieval software.
4. Servicing of datalogging instruments.

3.1 Wind Powered Battery Charger

One Wind powered battery charger of 12V, 72 Watts capacity was installed at Maitri Automotive workshop for charging batteries used for vehicles during winter months. The machine was giving uniformly good service until August 98. After eight months of operation it was reported that the rotor got jammed. The machine was subsequently inspected and it was found that the main bearings were completely damaged.

3.1.1 Electronics related problems

During X V H expedition it was noticed that there were some difficulties with regulation of output power from the machine. A specially designed voltage regulator that would take care of over voltage and over charging of batteries was designed, deployed and tested in XVIII expedition. Figure 1 shows the block diagram of the controller circuit and figure 2 shows the controller deployment near automobile workshop at Maitri.

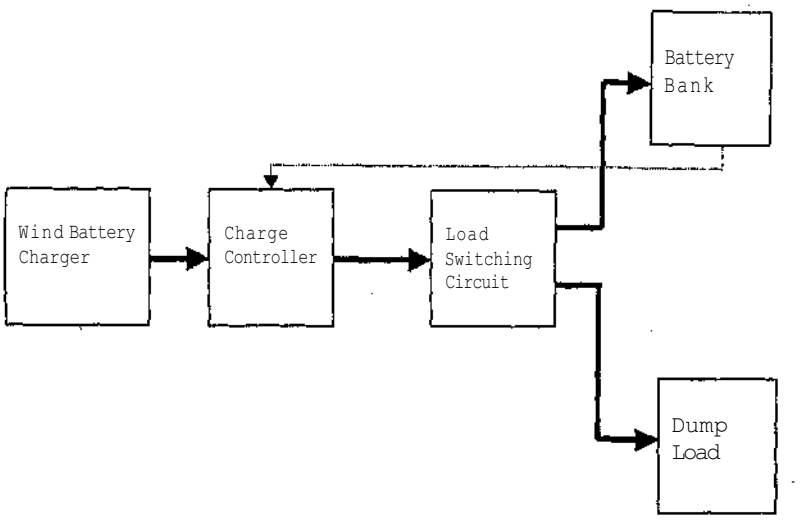

Fig.1

2.1.2 Performance and Failure of W T G

On return the W T G was inspected thoroughly and it was found that, The rotor blades, Yaw bearings, furling mechanism and its bearing were intact.

The main bearings of the generator, which also support the rotor blades, were completely damaged. The steel balls had come off pushing away the seals and had caused severe damage to the windings and it was also found that the femte magnets were fragmented. The generator was beyond repair. Figure 3 shows the damaged generator parts.

Based on the available wind data the bearing life was estimated and it was found that the bearing failure was to be expected 8 to 9 months of operation in the wind environment at Maitri.

To calculate the life of ball bearings used in the wind Generators, the following assumptions have been made:

1. The machine achieves a Tip Speed Ratio of 4 at all wind speeds.
2. The total number of revolutions in any given hour is governed by this.
3. The drag coefficient on the windmill blades remain constant a 0.9 and the radial load governed by the blade weight and centrifugal forces.

The number ofrevolutions completed over one year duration is estimated by:

$$R = \sum_{i}^{8760} (V_i * \lambda * 3600) / (2 * \eta * r)$$

Where

V_{wi} – Hourly average Wind speed in m/s
λ – Tip speed ratio (ratio ofblade tip velocity and wind speed)
r – Radius of the rotor (0.44 mts.)
i – Hourduringwhich Average Wind speed was Vi
R – Numberof revolutions

Number of revolutions of the rotor based on the calculations for the period of one year worked out to 93247 million revolutions. The calculated bearing life with the loading conditions and gyroscopic moments worked out to 105 million revolutions.

One machine was left behind at the vittaiah peak where the repeater station is located. And this machine was to be used for microwave communication purposes during winter months and convoy operations.

3.2 Wind Monitoring Activities

Wind Monitoring station was installed during XVI Expedition and the wind data was regularly collected and it was analyzed at National Aerospace Laboratories to understand the wind environment at Maitri. This activity was continued during XVIII expedition. In summer period, NAL scientist was collected the wind data and during winter period this work will be carried out by one of the winter teammembers.

Special type of Ice-free Anemometers and Wind vanes are used in the station. These anemometers and vanes need to be serviced once in a year the sintered bearings in the wind sensors are to be replaced once in a year to minimize malfunction and erroneous reading. This was carried out in all the five sensors and refitted. Figure 4 shows the dismantling process of wind sensors and instrumentations. A Microprocessor based data loggers were deployed to store the wind data, these instruments were checked for their proper functioning. The data stored in the EEPROM were being retrieved using slightly dated software and a new upgraded version was installed on the station computer. The special serial cable that connect the EEPROM reader to the personal computer had developed some snags. This was rectified.

During winter, the job of periodic inspection, wind data collection and transfer of data from Maitri to NAL through Email was carried out by R&D E scientists during earlier expeditions. In XVIII Dr.Barua, Scientist from NGRI Hyderabad took expedition the responsibility. He was given full training on EEPROM replacement, data downloading and data transfer.

4.0 Conclusions

1. The wind powered battery charger can provide very useful inputs to the logistics of Antarctic expeditions.

2. Imported machines also develop serious snags over some periods of operation.

3. There appears to be good scope for improving the design of small wind powered battery chargers.

A better option would be to design and develop a fully indigenous machine and test this in Antarctic environment. This has many advantages including repair, servicing etc., could be handled far more easily. Further, it is possible to take into account at the design stage itself the extraordinary environment that exists at Maitri and surroundings.

Acknowledgments

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Thanks are due to the Leader of XVIII ISAE, Mr.Ajay Dhar for his kind cooperation in all manner to carry out our work successfully within a specified period of time. Dr. Khare, DOD observer and Major Kadam and his team members provided good logistic support for the work carried out.

Dr.Barua, Scientist, from NGRT undertook to maintain the wind monitoring station through the winter and he did an excellent job. Thanks are due to him for his cooperation to continue the wind monitoring during winter period.

Finally we would like to thank all the Expedition members for their moral and technical supports. The entire staff of Wind Energy Department, NAL extended fullest cooperation on all aspects of the work in Antarctica. Authors are grateful to the team that made this expedition successful through their untiring efforts.

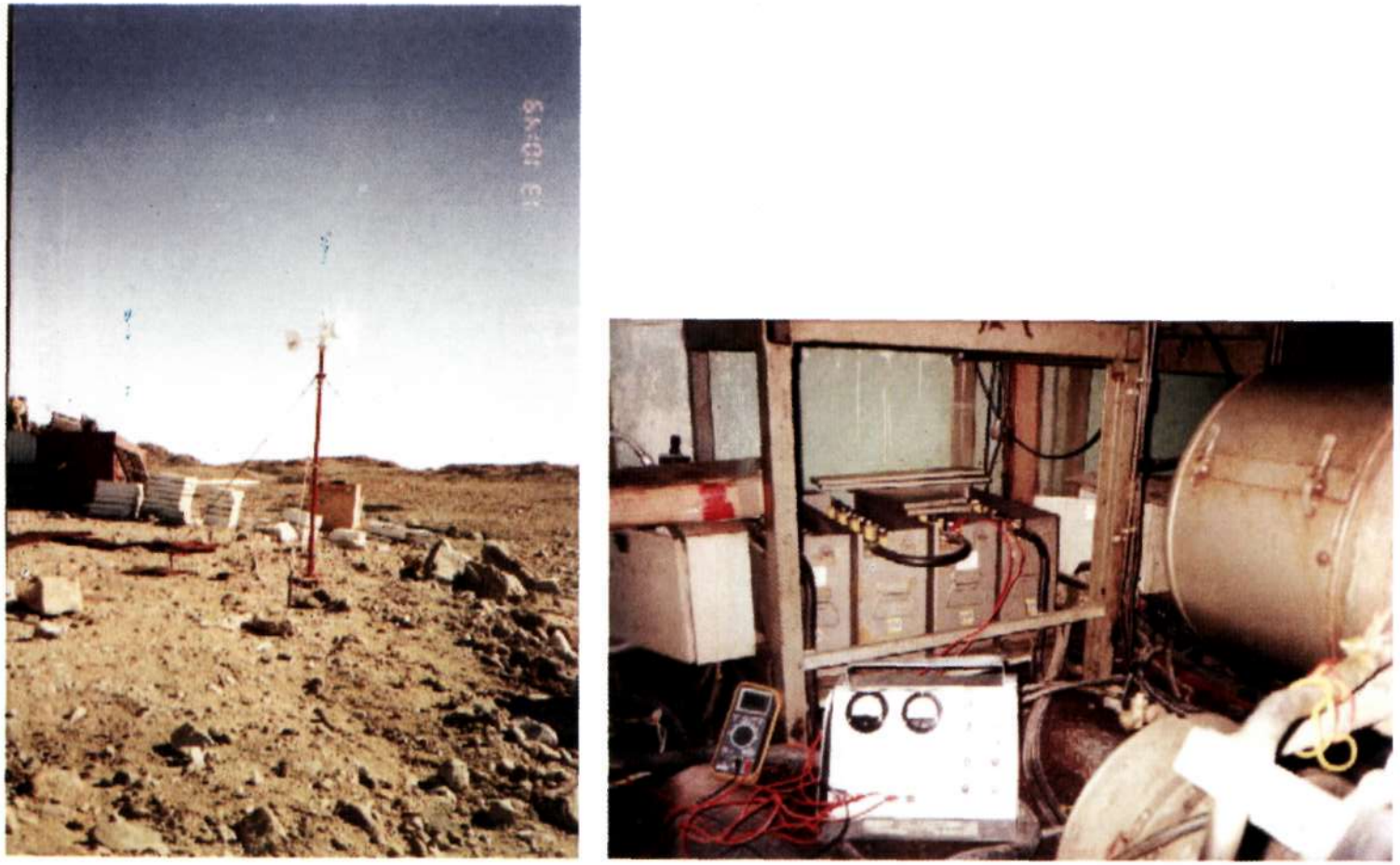
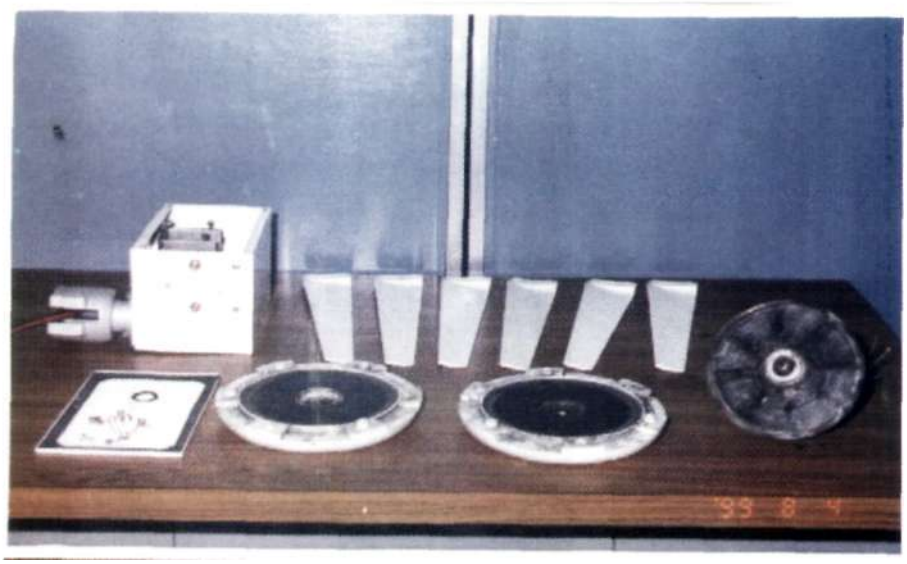


Figure 2: Installation at Workshop and testing in progress



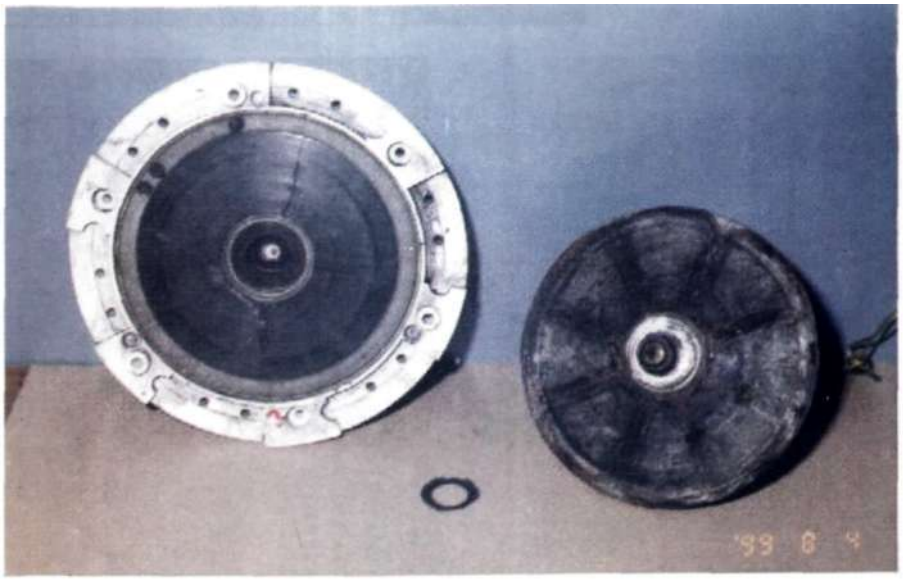


Figure 3 Damaged wind battery charger parts

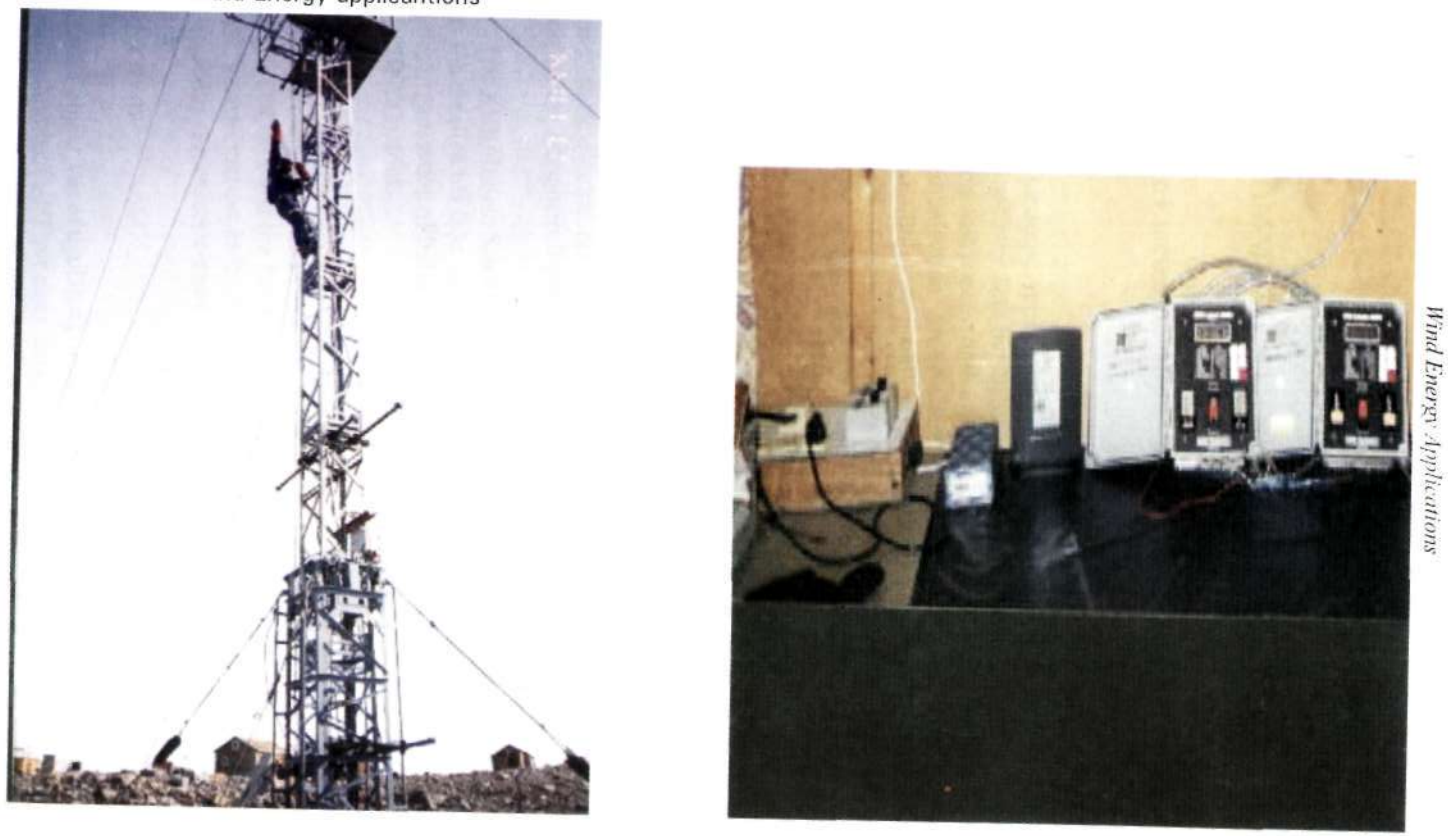


Figure 4. Wind monitoring set up at Maitri