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SCIENTIFIC AND ENGINEERING ACTIVITIES OF R&DE (ENGRS)

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Abstract

Research & Development Establishment (Engrs), Pune one of the pioneering scientific laboratory under Defence Research & Development Organisation (DRDO) has been actively involved with Indian Scientific Expeditions to Antarctica since 1983, III Indian Antarctic Expedition. State -of- the art Polymer Electrolyte Fuel Cell experiments were carried out during 1997-99 for the first time in Antarctica to study the feasibility and performance at sub-zero temperatures. Condition monitoring of Gensets based on Vibration measurements using COMPASS Machine Monitoring Software implemented successfully. Collection of strain data experienced by 28 m Mast to study and analyze the effect of high winds, intense blizzards and sub zero temperatures. Laying out of new water supply system with electrical trace heating, construction of underground Seismic Vault and Medical Complex were the major engineering tasks of XVII Indian Scientific expedition to Antarctica and XV Winter Over Team. Installation of the Water supply System and construction of Underground Seismic Vault were completed by the end of 1998 summer. After the preliminary work during summer period, the construction of Medical Complex started on 15 Oct 98 and completed by 17 Nov 98.

Introduction

Research & Development Establishment (Engrs), Pune, one of the DRDO lab associated with Indian Scientific Expeditions since 1983. During III Expedition indigenously designed and developed structures and equipment were sent to Dakshin Gangotri, India's first wintering station for trials in the extreme conditions of Antarctic winter and to develop the suitable Antarctic habitant.

Based on the experience since then and with continuous efforts, R&DE (Engrs) designed and developed India's second permanent station Maitri with indigenous materials and equipment. Maitri was constructed during 1987-89 where in twenty six members can comfortably stay and pursue their studies in harsh conditions of Antarctica.

In continuation of studies at Antarctica, following members from R&DE (Engrs) participated in the XVII ISEA:

i) Shri. KR Sivan - Winter
ii) Shri. Prasad Goud - Winter
iii) Shri. Kulbhushan Rai - Summer
iv) Shri. S Sen - Summer
v) Shri. BM Shaligram - Summer

The assignments, Scientific and Engineering activities, for the members during summer and winter period are given below:

Scientific Activities :

1. Polymer Electrolyte Fuel cell (PEFC) Experiments.
2. Condition Monitoring of Gensets.
3. Measurement of Strains experienced by 28 m Mast.

Engineering Activities :

Apart form the Scientific activities, R&DE (Engrs) was entrusted to provide the technical assistance to the logistic team in various engineering activities that include:

1. Installation of Water Supply System.
2. Construction of Underground Seismic Vault.
3. Construction of Medical Complex.

Scientific Activities

Fuel Cell (Polymer Electrolyte Fuel Cell - PEFC) Experiments

Fuel Cells are electrochemical devices with no moving parts that convert chemical energy into electrical energy. There are various types of fuel cells and they are normally named for their electrolyte. The most advanced fuel cells include Phosphoric acid. molten carbonate, solid oxide, proton exchange membrane and Alkaline. World wide experiments are going on to develop Fuel Cells for various applications to counter the air pollution.

At present, electricity is produced by thermal generation using diesel engine driven Gensets to cater the needs of Maitri. The major draw backs with the existing system are air pollution by gaseous exhaust, fuel cost, availability in the near future and difficult transportability from shelf to Maitri. Fuel cells as power generators could be a better alternative at Maitri because of their high efficiency high power - to - weight and volume ratios, their reliability, purity of energy, noiselessness etc. PEFCs are expected to operate at low temperatures and are more reliable. A 500 watt PEFC stack with Hydrogen gas as fuel and Oxygen as an oxidant experimented during 1997-99 to study the performance at sub zero temperatures experienced at Maitri and to study the performance of stack with various commercially available Hydrogen.

During the transportation of PEFC 500 Watt stack from MV Polar Bird to Maitri by helicopter, underslung mechanisms foiled and load crashed on the pack ice. The flowmeters, humidifier bottles and other external circuitry was completely damaged though the cell assembly does not sustain much damage. After thorough inspection of the stack, it was revealed that if flowmeters can be managed the stack can be made operational. Later a search was launched within the station and in the neighboring Russian station for suitable flowmeters. No suitable flowmeters found expect the flowmeters used for anesthesia purpose in the MI room.

As an experiment, two such flowmeters were improvised to suit the PEFC stack and the Cell was put into operation. Cell

developed the rated open circuit voltage 20 V. This is one of the big breakthrough and it proved the functionality of Fuel cell at this icy continent. The Cell experiments temporarily aborted as arrangements have been made by R&DE (Engrs) to send new stack through Russian Vessel Academic Fedrov, arriving Antarctic in June '98.

New Fuel Cell stack reached Maitri on 14 July 98 and the experiments were started in one of the summer huts keeping Hydrogen and Oxygen cylinders outside the hut. It was observed that the gases used to freeze in the gas carrying pipes due to sub-zero temperatures, small diameters of pipes and high differnce between storage and operating pressure. The typical freezing of gas was thirty minutes. The Cell develops output as per the specifications for thirty minutes and after that the performance drastically reduced. To counter this, Asbestos strips of 3mm were wrapped around the pipes carrying gases. Cell performance was satisfactory and no freezing of gases noticed even at the lowest temperature (-35oC) experienced at Maitri. The Fuel Cell was commissioned on 15 Aug 98 to commemorate the Golden Jubilee year of Independence by Dr Kiselev Valdislav, 43 Russian Antarctic Expedition Thereafter, the Cell was experimented with varying loads at different temperatures using three commercial grades of Hydrogen.

Commissioning of Fuel Cell on 15 Aug 98
by Dr Kiselev Valdislav, 43 Russian Antarctic Expedition

Condition Monitoring of Gensets

4 X 62.5 KVA, 4 X 62.5 KVA and 2 X 75 KVA gensets are commissioned at Surya, Aditya and Bhaskara power complexes respectively to meet the power requirements of Maitri. At any given time, two gensets are running continuously to cater for various loads. Gensets are an important life support system of Maitri and needs to be continuously monitored and maintained. Remote place like Antarctica demands On - Condition maintenance, also called Predictive maintenance since expected breakdown of a machine is predicted through regular condition monitoring in contrast to Run-to breakdown maintenance and Time-based maintenance. In case of any failure, the genset will be idle as the spares could be transported only once in an year.

All mechanical devices have the properties of mass and elasticity, and therefore posses the ability to vibrate. If the perfect device was built then it would have ideal vibration characteristics, i.e. it would not vibrate. However, in the real world, all machinery is built to tolerances and as such will vibrate. Vibration problems occur wherever there are rotating or moving parts in a machinery. Apart from the machinery itself, the surrounding structure also faces vibration hazard because of this vibrating machinery. The main causes of the vibration are: Unbalanced forces in the Genset, Damage to rolling element bearings, Dry friction between two mating surfaces, Misalignment, Increased turbulence of lubricating oil, External excitations etc. The effects of vibrations are excessive stresses, undesirable noise, looseness of parts and partial or complete failure of parts. Condition monitoring of gensets based on vibration measurements implemented to avoid catastrophic failure of gensets with the help of COMPASS 7616 vibration monitoring software, Bruel & Kjaer 2526 data collector and Piezoelectric accelerometer. Vibration levels at critical points measured using piezo sensor and data collector. The software compares the vibration levels with reference levels and generates alarms to initiate maintenance action, if any.

Auto Spectrum is used to get the overall condition of the genset and Envelope spectrum for detailed analysis at different frequencies. Any increase in the vibration level is indicative of

developing fault and their frequency will enable to predict the probable fault. With auto and manual trending tools it is possible to estimate the lead time available before breakdown.

This is ongoing project of R&DE (Engrs), proved to be very handy in diagnosing the developing faults and to initiate predictive maintenance quite a number of times that prevented breakdown of the gensets. Few such results are outlined here:

a) Looseness of foundation bolts of Surya Genset -2.
b) Misalignment of coupling between engine and alternator of Bhakara-2.
c) Diagnosing of common faults like, unbalanced forces and mechanical looseness.
d) Prediction of Bhaskara-1 engine faulty air blower and idler pulley assemblies.

Measurement of Strains experienced by 28 m Mast

28 m Mast designed and developed by R&DE (Engrs) erected during XI Indian Expedition to Antarctica (1991-93), approximately 250 m from the main block for mounting the National Physical Laboratory (NPL), New Delhi antennas. Thereafter it has been used for mounting various sensors and instruments for various studies by different establishments. The mast has been subjected to high wind speeds, intense blizzards and low temperatures for more than nine years. To study the effect of these loading collection of strains were initiated. During the summer period, four strain gauges on mother truss of the mast and one strain gauge on base plate of South East and South West winches were bonded. The cables were laid in a conduit from one of the summer hut, Nanda Devi, where instrumentation was installed. Strain data at these locations of the mast collected using quarter bridge configuration with strain indicator and switch and balance units.

Engineering Activities

Members from R&DE (Engrs) actively participated in the following engineering tasks and provided technical and all assistance to accomplish the tasks.

Water Supply System

Maitri is provided with water from the adjacent Priyadarshini lake (approximately 255 metres away) through a specially designed pipeline and pumping systems. The pump house is located at a distance of approximately 80m from the bank of the lake. The pumphouse is provided with two submersible pumps with stainless steel housings and a self priming centrifugal pump. The stainless steel housing is heated electrically using trace heating tapes. The pipline is approximately 300 m long from the pump house to the storage tank in the main station. It is made up of 40 mm diameter copper pipes of 6 m length, press fitted to each other using brass ferrule and collar type joints. Two such pipe lines are housed in a rectangular insulated duct fabricated out of Marine Plywood and 100 mm rigid PU foam. The temperature of the duct and copper pipeline is maintained by electric trace heating system. Only one pipeline is used for daily pumping of water and other is a stand by. Due to breakdown of entire system during the wintering period of XIV WOT, it was planned to lay out two copper pipelines with electric trace heating system to have uninterrupted water supply.

The water supply stores were brought from 07 January 1998 onwards by the helicopters on priority basis as planned during the voyage. Once the required stores were inspected & collected on site, laying out of pipeline and installation of trace heating tape was initiated. After thorough inspection of existing pipeline it was decided to lay only one new pipeline and carryout modifications/ necessary repairs to the existing pipeline for stand-by measures. The work executed is basically categorized into the following steps:

a) Duct inspection, numbering & leveling of the sagged pipeline (sagging of ducts due to vintage).
b) Fitting of brass ferrules and collars on to the pipes.
c) Laying of pipeline in the duct.
d) Pumping of water through the new pipeline and checking for leaks/ rectification of the same.
e) Testing and external laying out of trace heating system.
f) Fixing of trace heating tape on to the pipeline in

three approximately equal parts for load balancing/ distribution. This will also ensure ease of maintenance and repair.

g) Installation of junction boxes, temperature sensors and indicators.

h) Repair of the damaged portions of the existing (old) pipeline.

j) Closing of the duct.

The complete installation and final testing of water supply system was completed by 16 Feb 98. Repairs were carried out to the existing system basically by replacing damaged copper pipes, joints and rubber hoses. The performance of both the systems was satisfactory throughout the wintering period of XV WOT.

Construction of Underground Seismic Vault

Construction of Underground Seismic vault for National Geophysical Research Laboratory (NGRI), Hyderbad was one of the major task of XVII Expedition. The seismic vault is a room having approximate 2.1m X 1.8m X 1.9m size with an entrance from the top for installing three component seismic sensors. The vault was buried up to a depth of 1.7m leaving 0.2m above the ground level. Due to the loss of the fitment items like hinges, bolts, screws and nails in one of the underslung failure of the helicopter sorties, available fitments at Maitri were improvised to construct the vault.

Being an underground structure, the major hurdle was the excavation of a pit. This was mainly accomplished by manual methods with a little help from the dozer as the site was rocky and the soil was hard due to permafrost. Explosives couldn't be used considering the near by summer huts, labs and 28m mast. The dimensions of the pit had to be much larger than the vault to accommodate the 2.1m X 1.8m vault base. After requisite depth was reached a rough plain surface was made using gravel and stones. Onto this rough surface, precasted blocks of 2.0m X 0.6m X 0.1 m dimensions (which were locally available at Maitri) were placed so as to protrude by 15-30 cm from all sides of the seismic vault. The alignment of the vault was done as per the requirements of NGRI with longer axis of the vault along with the North South

axis. The construction of the vault WHS done as per the construction sequence in the instruction manual given by R&DE (Engrs). The sensors and instruments were installed with cabling into the near by Tirumala hut. The vault was provided with a temperature controlled heating system, which maintains the vault at a temperature of 15°C. The vault was inaugurated by Mr. Alexander Kendratiety, Leader 42nd Russian Antarctic Expedition on Indian Republic Day (26 Jan 98). NGRI successfully carried out seismic observations without any problem round the year.

Construction of Medical Complex

Medical complex was designed based on the concept of housing the structure within the existing 'A' Block of Maitri. Accordingly, based on the onsite measurements provided from Maitri, the Medical complex was designed & inducted to Maitri during the XVI Expedition, but due to certain problems the same couldn't be constructed by XVI Expedition Team resulting in stalling of the project for one year. The construction of the medical complex was entrusted to XVII IAE and the problems were looked into during the summer period of XVII IAE by a technical team comprising:

a) Mr. K R Sivan — Leader, XVII IAE (XV WOT)
b) Mr. K B Rai — Summer Member, R&DE (Engrs)
c) Capt. K S Panesar — Stn Engr, XVII IAE (XV WOT)
d) Mr. A Prasad Goud — Member, XVII IAE (XV WOT)

Subsequently, after carrying out detailed onsite study of the technical problems the following deviations / modifications from the original design were resorted to have ease in construction:

a) The extension shelter was done away with.
b) To start the construction of the Medical complex from bay no.3 (w.r.t Maitri side), instead of bay no.l so that remaining space can be used purposefully.

The broad sequence of construction procedure implemented was as follows:

a) Clearing of 'A' Block and removal of debris.
b) Breaking of four concrete foundations of the erstwhile generators housed within the 'A' block.
c) Preliminary leveling of the flooring of 'A' block.
d) Laying of floor panels and checking of cam locks and inter connectability of the same without cutting.
e) Insitu cutting of floor panels to accommodate the existing nibs protruding from the side walls of the 'A' block.
f) Fitting of side walls and end walls except the end wall on Walk -in-Freezer side of 'A' block.
g) Cutting and fitting of roof panels.
h) Fitting of end walls on Walk-in-Freezer side of 'A' block.
k) Fitting of flashing and corner angles on the outside.
1) Fitting of the internal partition walls and doors.
m) Fixing of the corner angles and various flashing provided.

The entire construction activities were completed by 17 Nov 98 and the Maitri Medical Complex was inaugurated on 18 Nov 98 by Mr. Alexander Kochin, Leader 43 RAE on the occasion of the 218 th Corps of Engrs Day

Additional Responsibilities

National Aerospace Laboratory(NAL), Bangalore installed **a** 75 watt wind turbine near workshop area for charging the batteries. In addition, they have three wind sensors and one direction sensor mounted on the 28m mast to procure the wind data over a year with a view to design wind turbines for Maitri. As there was no wintering member from NAL, monitoring of wind turbine, wind sensors and data loggers were assigned to the wintering members of R&DE (Engrs). Wind data collected round the year without a break and the same was transmitted to NAL through e-mail for further processing. Wind turbine functioned satisfactorily till 26 Oct 98 and developed a problem during intense blizzard with high wind speeds and gust ranging as high as 80 kt.

Station Activities

Earthing system developed by R&DE (Engrs) performed satisfactorily and the maximum earth leakage noticed was 21 V, which was well below the specified limits. Electrostatic charge was acquired and monitored through out the year. At required places electrostatic mats and ionizers installed with earthing connection. A maximum static charge of + 5 kV (DC) was noticed during 14 May 98. It was observed that static charge was high during high winds, snow drifts, blizzards and during polar nights. Monitoring of walk-in- freezers carried out and performance was satisfactory. One freezer was replaced with spare one, as it requires recharging of Freon -502. The defective one was backloaded for filling of Freon-502.

Conclusions

PEFC experiments demonstrated the suitability of PEFCs for use at Maitri. The Cell performed satisfactorily at lowest temperature -35°C recorded during this season. Condition Monitoring of Gensets based on vibration measurements was very effective in predicting and diagnosing developing faults of gensets and to avoid major breakdown. Strains experienced by 28m mast collected manually to access and analyse the effect of high wind, intense blizzards and low temperatures. A new water pipe line of 300 m length laid down with electric trace heating tape and the performance was satisfactory through out the wintering period of XV WOT. An Underground Seismic vault was constructed to install three component sensors of NGRI to pursue seismic studies. A full fledged Medical Complex was constructed in the existing 'A'block with minimum changes to have ease in construction and better utility of the remaining space. Wind data collected uninterruptedly and forwarded to NAL for further processing through e-mail. Additional station activities like monitoring of earthing, static charge walk in freezers successfully accomplished. Activities which started during summer but could not be completed were successfully completed.

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Installation of new pipe line with electrical trace heating

Renovated boiler room