DEVELOPMENT OF AN INDIGENOUS FOG CHAMBER FOR INSULATOR TEST

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ABSTRACT

This paper presents the development of a complete mobile fog chamber system, which encompasses the aspects of electronic instrumentation, video recording, fog generation system, high-voltage source, data acquisition system and monitoring instrument. The chamber has all the basic features to conduct type-tests on insulator of ceramic and non-ceramic type in an environment of artificially polluted condition. The design and construction of this chamber was simple, effective and efficient. The experience and insight gained in the present work is expected to benefit others. IVAT (Institute of High Voltage and Current) can be considered as resource centre of the subject.

1. INTRODUCTION

In the last decade tremendous effort has been put to understand the performance of insulators especially the polymeric insulator [1,2,3]. Many researchers have adopted various testing procedures to observe the performance of the insulator exposed to prolonged contaminated condition. Various types of testing were conducted on the insulator and invariably an artificial contamination chamber was used [4].

Some parameters had to be considered in the development of an artificial contamination chamber system, particularly in dimensioning of the size of chamber as well as laboratory space availability. Every chamber components has to be appropriately designed and suitably located to ease the chamber installation. This will facilitate the ease in organizing the various activities of testing work, reduction of development cost, and minimal space utilization. Regarding the sizes of chamber, it is divided into three categories, i.e. large size, if at least one of its dimension is greater than 5.0m, medium size, if at least two of its dimensions are between 1.0m and 5.0m, and small size, if it main dimension is less than 1.0m [5]. Generally the size of chamber developed is related to the working voltage to be used in the test. For the medium size, there are numerous publications on this subject.

In this study, a mobile fog chamber was designed, developed and constructed in the laboratory instead of acquiring a commercial one which is so expensive to purchase. The fog chamber's development was intended to simulate the real service condition so that tests can be conducted in the laboratory. In this way, time saving tests or accelerated tests can be conducted on insulators.

2. DESIGN OF THE CHAMBER

In every engineering works proper design practice is essential to obtain the best practice result on implementation. Therefore technical drawings are required to provide an illustration of implementation work. This is also important to obtain some information regarding the amount of materials required, appropriate size of the relevant equipment, the optimum and suitable location of the relevant objects, scope of works, cost estimations and time saving in implementation.

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The technical drawing was materialised by means of AutoCAD, which is currently among the most powerful software for a technical drawing. The AutoCAD can help to produce the design in three dimension and also orthographic presentation [6,7]. Fine detailing of the drawing design, zoom in and zoom out drawing and editing of the drawing is easily done with AutoCAD aided design.

3. DEVELOPMENT OF THE CHAMBER

The development of mobile fog chamber was divided into four main parts, i.e. chamber construction, contamination generation system, electronic equipment, and HV source unit. The chamber was of cubicle in shape with 1.415m x 1.415m x 1.650m (W x L x H) in dimension. Fig. 1 illustrates the block diagram of the mobile fog chamber. Fig. 2 shows the view of the chamber and view of observing and collecting system unit.

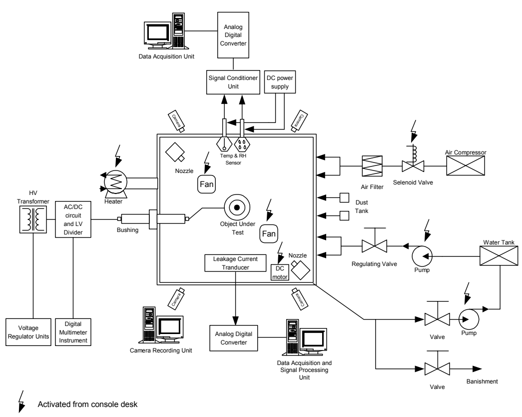
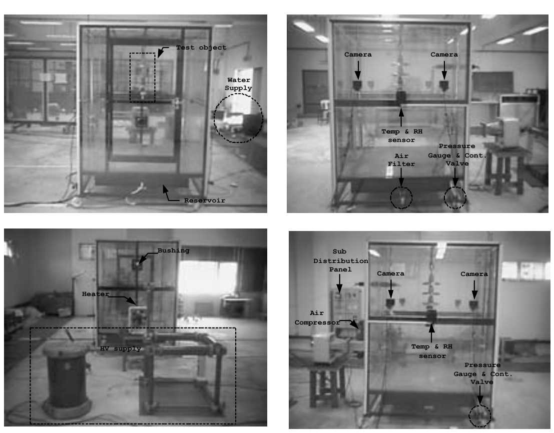
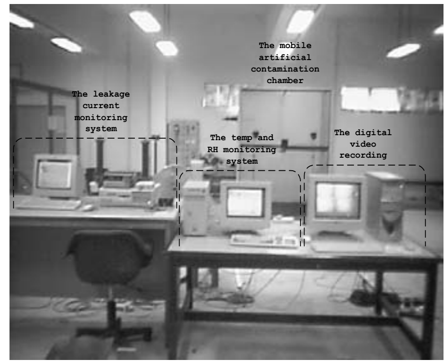


Fig. 1 Block diagram of the fog chamber.



(a)



(b)

Fig. 2 (a) Views of the fog chamber, (b) views of observing and collecting system unit**.**

3.1 Construction of the Chamber

The most important activity in construction work was assembling of the chamber steel structure. The steel base frame has to be welded perfectly. All components were angle elements for their mechanical strength. The mechanical connection of the chamber structures with the four nylon wheels was executed carefully. The chamber walls were made of transparent (see through) plastic material. Polycarbonate sheets were selected due to their impact strength, thermal stress resistance, construction flexibility and chemical inertness. The polycarbonate sheet is more superior to that of acrylic materials. Acrylic tends to become brittle with time, whilst polycarbonate does not.

In Fig. 1, the supply of AC/DC voltage to the test object was via a bushing, which was sticking through the wall of the chamber. A galvanized steel hanger was fixed at the centre of chamber roof, allowing any insulators under test to be suspended vertically.

3.2 Electronic equipment

3.2.1 Temperature monitoring system

For chamber ambient temperature monitoring, two integrated-circuit temperature sensors were installed. The output voltage of sensors was linearly proportional to the Celsius (Centigrade) temperature. The sensors did not require any external calibration or trimming to provide typical accuracies of ± ¼ °C at room temperature and ± ¾ °C over full -55 to +150 °C temperature ranges. They had low output impedance 0.1Ω for 1mA, linear output +10.0mV/°C scale factor, and precise inherent calibration make interfacing to readout or control circuitry especially easy and could be used with single power supplies, or with plus and minus supplies operates from 4 up to 30 volts. It is suitable for remote applications [8].

3.2.2 Humidity monitoring system

The sensors of choice were designed for straight use. Resistance of the sensor decreases with increasing RH. This sensor provides linear voltage output, 1.5 – 3.0Vdc, with humidity variation in order of 25 and 100 percent. Some of the advantages of the sensor, among others were ease to install and reliable. It worked at 5±0.2Vdc and maximum current 2mA. It could be applied in respect to humidity monitoring, humidity controlling, air conditioning, humidifying, dehumidifiers, and automatic ventilating [9].

3.2.3 Digital video recording (DVR)

Flashover scenario on the tested insulator surfaces was observed by means of a DVR system. It was a compact-application-equipment for a real-time monitoring system. It grabbed images from a CCTV. Clear and more vivid images could be monitored and recorded. The DVR board was installed with a Pentium-4 PC.
Four CCTV cameras were placed on the exterior sides of the chamber as shown in Fig. 1. By this way the whole surface phenomena of the insulator test object could be observed. Fig. 3 illustrated the records of flashovers during insulator testing.

Fig. 3 Typical snap shots of the insulator flashover on the insulator surface.

3.2.4 The Fog Generation System

Among the components installed in the fog generation system, the installation of two nozzles-units was the most challenging task to accomplish. The nozzles-unit was place into an adapter securely. A hollow cylindrical stainless steel bar was erected located at the opposite corners of the chamber. This bar supported the adapter. The adapter unit could be moved up and down easily. In addition, lock and release toggle was also provided. Fig. 4 illustrates the nozzles units.

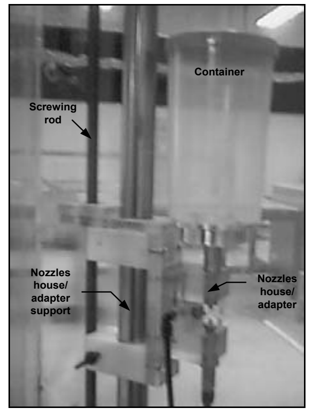


Fig. 4 The nozzles-unit mounted in the chamber

The nozzles-unit was supplied with salt-water and air. The flow rate of water and air of each nozzle could be adjusted to change the water droplets' size. The air pressure could be set to a value up to 80.0psi. The water and airflow rates were controlled with a mechanical unit valve (MUV). A compressor supplied the airflow. A solenoid valve was installed and had the means to switch on/off the airflow. The filter functioned to filter any foreign particle, such as water or oil that could attach with air. For the simulation of the artificially non-soluble particle contamination, a container was connected to the nozzle. These particles dropped into the compressed air blowing area of the nozzle unit by gravitational force.

3.2.5 Data Acquisition System

Signals generated from the sensor units were analog signals. These analog signals were converted to digital signal prior to sending to PC. The Pico Analog Digital Converters (ADCs) were used for the purpose of interfacing sensor units with the PC.

3.2.6 Pico ADC-11 and ADC-200

Pico ADC-11 was used for monitoring, while Pico ADC-200 was used as an interface for the leakage current signal measurement [10,11].
The leakage current that was flowing through the contaminated surface of the insulators under test was monitored, digitised, processed, displayed and finally stored for further analysis. The voltage drop across the shunt (due the leakage) was monitored. A surge protector was put in placed between the shunt and ADC-200. The protective system consisted of 2 (two) stages. In this manner if one stage experienced

total failure the backup could protect the ADC and PC. Fig. 5 illustrates the leakage current measuring circuit.

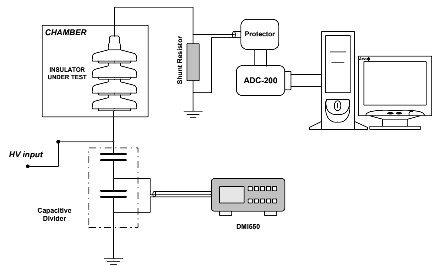


Fig. 5 Leakage current measuring circuit

3.2.7 Monitoring Instrument

LabView 5.11 virtual instrument software was used as the platform for the monitoring instrument development. The software is an icon based-program. The software has facilities that include the database result window, graph window, and other function buttons. Using the software, data reading can be visualized [12]. Two monitoring instruments were developed, i.e. for the leakage current and for the chamber ambient condition monitoring.

Fig. 6 illustrates the monitoring instrument for the leakage current measurement and the chamber ambient condition monitoring.

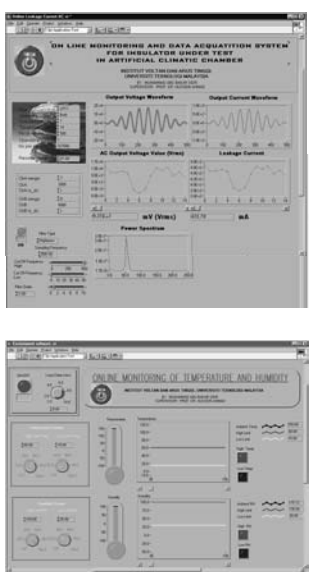


Fig. 6 Monitoring instrument for leakage current measurement and the chamber ambient condition.

4. CONCLUSION

A mobile fog chamber together with the electronic instrumentation, video recording, data acquisition and monitoring instruments, has been designed and fabricated. Leakage current and flashover simulation incidents could be monitored, recorded and visualized. The mobile fog chamber was satisfactory and could be used for ceramic and non-ceramic tests. This chamber with dimension of 1.415m x 1.415m x 1.650m is in the category of the medium-scale climatic chamber. Usually such a size is not commercially available in the market. The experience and insight gained in the present study has been described in details in this paper so that others can benefit from this.

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