APPLICATION OF INFRARED CAMERA FOR MONITORING OF TRANSFORMER BUSHING

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Abstract— Failure of power transformer results in a serious damage to assets and reliability of the power system. Power transformers bushing are often checked with thermal imaging camera. Temperatures of the high voltage connections can be compared so that, if necessary, corrective action can be taken before real problems occur. This paper deals with the practical importance of the transformer bushing hot spot diagnostic using infrared camera in the Electrical power system

Index Terms— Thermal infrared camera, transformer, bushing, faults, hot spot.

I. INTRODUCTION

Transformer is a static device used to transfer electrical power from one circuit to another by electromagnetic induction. In electrical power system transformers are important components and represent very large investments. Like all electrical devices faults also happen in the transformers which cause failures [1]. The fault can also be very dangerous as the transformers contain large quantity of oil in direct contact with high voltage components. This increases the risk of fire and explosions due to failures. Different faults are caused by different reasons, which all have different impacts on the power system. In this paper some of the most commonly occurring failures are discussed with their causes and corrective action. Transformer failure analysis shows in average about 10% of transformer failures are caused by bushings damage which is often followed with disastrous consequences [2]. This percent is essentially more for large transformers.

Therefore, it is preferable to predict by predictive maintenance tools these faults before their actual occurrence to prevent the expected damage, which can be accomplished by thermal imaging, Infrared camera [1]. Comparing thermal images at normal and abnormal conditions would simplify many diagnostic techniques. With aids of thermal imaging, the operator can maintain and monitor all equipment by just observing their thermal images captured routinely and displayed on a monitor, even from remote locations. So, this can improve safety and reduce man power and maintenance time. Since overheat cannot be visually recognized in some devices, thermal imaging monitoring has to be utilized to prevent sudden accidents.

II. BUSHING USED IN TRANSFORMER

According to IEEE/ANSI std. electrical bushing is defined as "an insulating structure, including a through conductor or providing a central passage for such a conductor, with provision for mounting a barrier, conducting or otherwise, for the purpose of insulating the conductor from the barrier and conducting current from one side of the barrier to the other."

Figure 1: condenser bushing

Two common types of transformer bushings are used, namely, solid porcelain bushing for smaller transformers and oil filled condenser bushings for larger transformers (also called oil impregnated paper (OIP) bushing). Solid porcelain bushings consist of high grade porcelain cylinders that conductor pass through. Outside surface have a series of skirts to increase the leakage path distance to the grounded metal case. High voltage bushing is generally oil filled condenser type. The construction details of a typical condenser bushing rated ≤69 kV is presented in figure [1].

Condenser types have a central conductor wound with alternating layers of paper insulation and tin foil and filled with insulating oil. Each conductive layer acts as a condenser and voltage equalizer. This results in a path from the conductor to the grounded tank, consisting of a series of condensers. The layers are designed to provide approximately equal voltage drops between each condenser layer.

A. Some of the main reasons for bushing failure are discussed below

- Loosening of conductors is caused by transformer vibrations which results in overheating. This heat damage the insulating paper and the oil used.

- Sudden high fault voltages causes partial discharge (breakdown of solid/liquid electrical insulators) which damage the bushes and causes its degeneration and complete breakdown within hours.
- Seal breaking of bushes happen due to ingress of water, aging or excessive dielectric losses. Due to this fault core failure of the transformer occurs.
- Not replacing of old oil over long time or its deficiency due to leakage causes internal over-flashing.

B. *Bushing troubles and its method of detection*

Table I: Bushing trouble

Bushing troubles		
Trouble	Possible result	Method of detection
Cracked porcelain	Moisture enters. Oil and/or gas leaks. Filler leaks out.	Visual inspection, Power factor test, Hot collar test
Electrical flashover	Cracked or broken porcelain	Visual inspection, Hot collar test.
Gasket leaks	Moisture enters. Oil and/or gas leaks. Filler leaks out.	Visual inspection, Power factor test.
Oil migration	Filler contamination	Visual inspection, Power factor test.
Loosening of conductors	Overheating	Thermal monitoring

Out of which loosening of conductor cannot be detected by visual inspection. The temperature of contact becomes higher than normal operating temperature which results in overheating of bushing finally malfunctioning of bushing. This may cause interruption of power at service end. This will not accepted by the utilities. Thus measure should be implemented to detect such overheating due to loosening of conductor, which can be detected easily by infrared camera.

III. THERMOGRAPHY

Infrared thermography is the science of acquisition and analysis of thermal information by using noncontact thermal imaging devices. Thermography is a technology that actually allows us to see thermal energy. Thermography can be used in any circumstance where the identification of thermal patterns can be used to diagnose a condition such as poor electrical connection. While infrared thermography has wide applications in condition based maintenance, R & D, medical, QC and Process Monitoring non – destructive testing and many others.

Infrared thermography is the technique that uses an infrared imaging and measurement camera to see and measure invisible infrared energy being emitted from an object. Thermal, or infrared energy, is not visible because its wavelength is too long for the sensors in our eyes to detect. It is the part of the electromagnetic spectrum that we perceive as heat. Unlike visible light, in the infrared spectrum, everything with a temperature above absolute zero emits infrared electromagnetic energy. Even cold objects such as ice cubes, emit infrared radiation. The higher the temperature of the object, the greater the infrared radiation emitted. The Infrared camera allows us to see what our eyes cannot.

IV. METHODOLOGY

Heat is an important factor in high voltage installations. When electrical current passes through a resistive element, it generates heat. An increased resistance results in an increase in heat. Over time the resistance of electrical connections will increase, due to loosening and corrosion for instance. The corresponding rise in temperature can cause components to fail, resulting in unplanned outages and even injuries. In addition, the energy spent on generating heat causes unnecessary energy losses. If left unchecked, the heat can even rise to the point where connections melt and break down; as a result, fires may break out. By using infrared camera hot spot on Y phase 132kV transformer bushing was identified as shown in figure [2].

Figure 2: Hot spot on 132kV Y phase bushing

It was found that the due to loosening of conductor contact overheated causing corrosion on connector as shown in figure [3]

Figure 3: overheated connector

After outage by replacing connector bushing was placed on transformer as shown in figure [4].

Figure 4: healthy connector

Once again thermal scanning was carried out on bushing showing the hot spot on 132kV Y phase bushing as shown in figure [5]

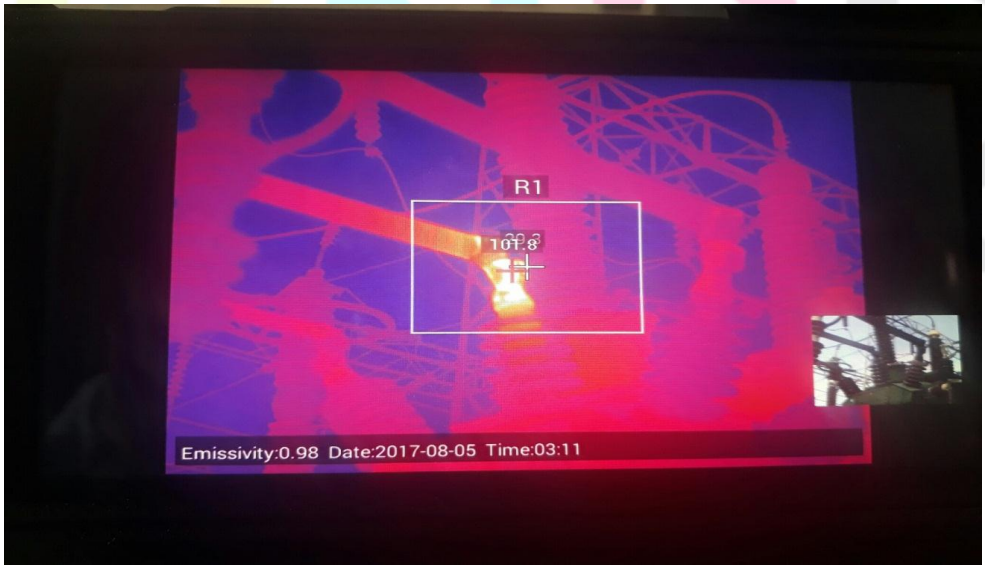

Figure 5: hot spot detected on Y phase of Bushing

After outage it was observed that internal bushing rod was damaged due to overheating. So bushing was replaced by healthy one on Y phase 123kV transformer. Thermal scan showing healthy functioning of Y phase bushing as shown in figure [4].

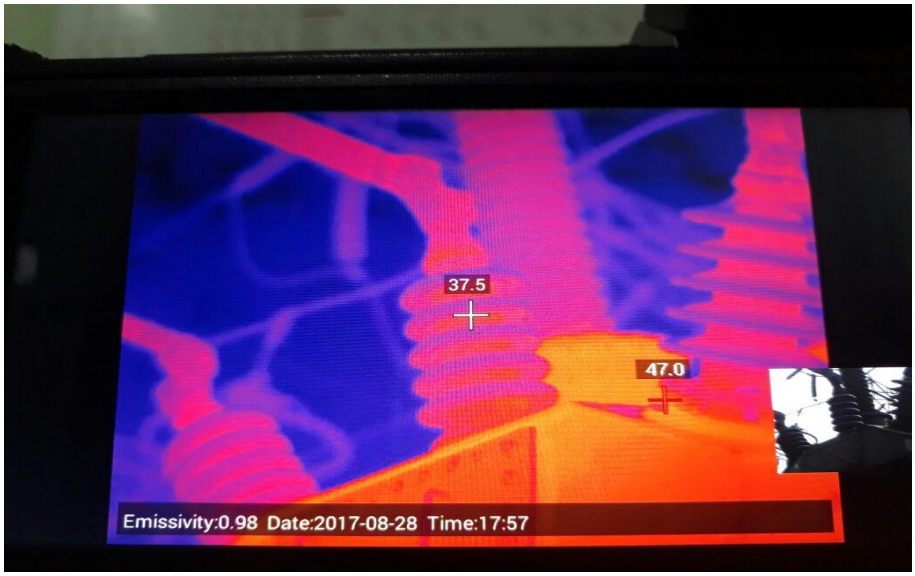

Figure 6: hot spot cleared on Y phase Bushing

In many occasions we have the experience to witness heavy electric sparks coming out from the bushing termination joints, especially on L.V connections. In most of the cases, these sparks are because of loose terminations during the course of installation or else have been loosen due to bad service conditions. Once spark occurs at the cable termination, it causes melting of the busing sealing gaskets, effecting oil leakage from the bushing top, resulting failure of transformer in due course of time because of low oil level Users must ensure that the cable connections have been done with proper lugs and connectors. Direct Connection of cable/conductor to the bushing terminal stud, should be avoided.

Table II: Temperature at bushing

Condition	Temp. at R-phase	Temp. at Y-phase	Temp. at B-phase	Status
1	37.5^0 C	107.6^0 C	37.5^0 C	Temperature rise detected on Y-phase
2	37.5^0 C	101.8^0 C	37.5^0 C	Temperature rise detected on Y-phase after outage
3	37.5^0 C	37.5^0 C	37.5^0 C	Temperature After replacing bushing

V. Conclusion

Thus by using infrared camera malfunctioning of bushing was detected which was not possible by any test and visual inspection. By replacing bushing in time 132kV transformer is continue to provide service without any interruption.

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VII. References

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