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PROTECTION OF POLE-MOUNTED TRANSFORMERS USING CIRCUIT BREAKERS

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ABSTRACT

The failure of pole mounted transformers (PMTs) due to over loading is a big issue in Pakistan. This issue has been taken into consideration in many developed countries like USA ,UK , Saudi Arabia and Japan etc .In order to protect the PMT ,a circuit breaker is mounted on the secondary side of the PMT which would trip when the load increases more than the limited capacity of the PMT .The first portion of this paper presents a brief discussion about energy distribution . The second portion presents a failure rate, causes of the existing protection of the PMT and third portion presents the working of the circuit breakers at different loads.

KEY-WORDS: Energy distribution, PMTs failure rate, causes and existing protections, circuit breakers and its beauty.

1. INTRODUCTION

Transformers are critical and expensive component of a power system .Oduction transformer is a basic component of power system and the history is linked with development in electrical power [1]. In practice, mostly PMTs are fully loaded continuously but load and temperature also fluctuate with seasons and time. There is a certain emergency overload capacity for the transformers. Overloading of PMTs is a big problem in Pakistan especially in the rural areas. Due to overloading, it heats up and gets damaged. The type of protection of transformers varies depending on the application and the importance of the transformers. Transformers are primarily protected against faults and overloads. The type of protection used must minimize the time of disconnection for faults within transformers. The countries such as United Kingdom, Russia, United States of America, Thailand and Saudi Arabia etc have installed concerned protective device e.g. Circuit breakers to prevent the failure of pole mounted transformers. For protection, a protective device must determine that when a fault condition develops and should automatically disconnect the PMT from the load. The circuit breaker will trip automatically when the current will exceed the rated limit and thus will prevent the PMT failure which is a big issue facing the underdeveloped countries like Pakistan. Most of the countries have installed MCB & MCCB etc which themselves are the cause of transformer failure because of their excessive current which melts the bimetallic strip in the breakers due to short circuit and transients .This can be prevented by using suitably rated Oil Circuit Breakers which will quench the transients.

2. POWER DISTRIBUTION:

Generation plants are required to convert fuels (coal, gas, oil, fossil, nuclear etc) into electrical power [2] Typically a prime mover rotates the alternator that generates voltages between 11KV and 25KV. Power is carried by transmission lines at high voltage to distribution section. Distribution sections have step-down power transformers with incoming high voltage lines and several outgoing medium voltage overhead 11KV lines (called feeder) or underground cables. Distribution transformers receive the primary distribution voltage i.e 11KV through primary feeders and step-down transformers and deliver them to be utilized at 230V for a single phase and 400V for a three phase system as shows in the figure.

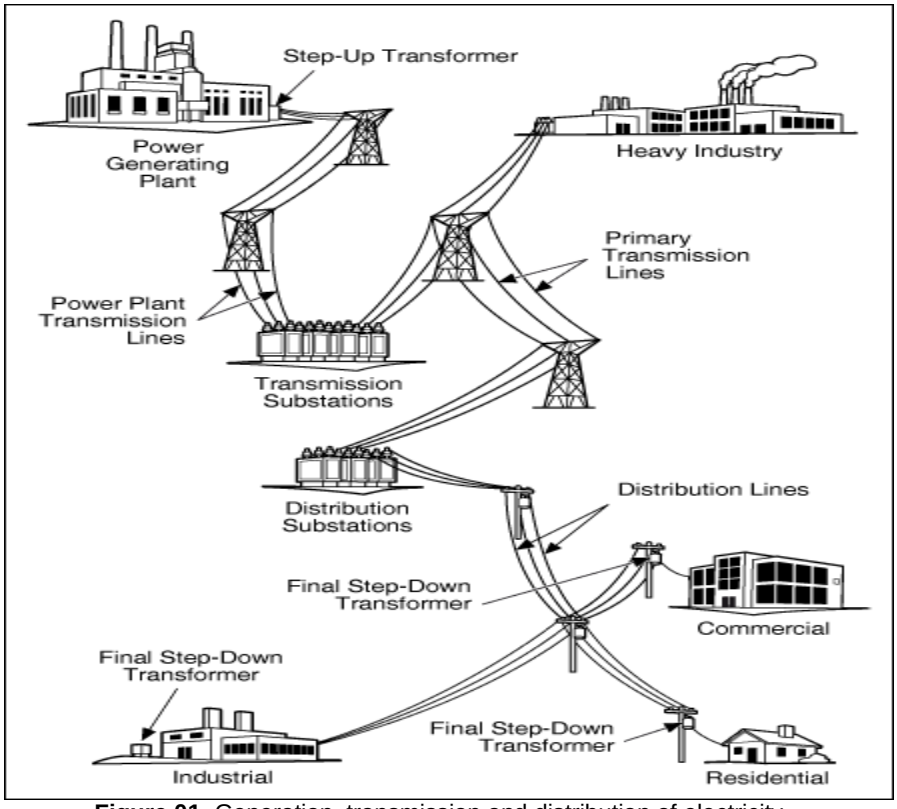


Figure 01. Generation, transmission and distribution of electricity

3. TMTs failure rate:

The failure of PMTs is increasing a lot per year not only in Pakistan but in other countries. A local utility in Saudi Arabia was suffering a high transformer failure incidence. IN a three year of period, it reported about 1150 failure per year. The average total population of the existing transformers in the network was around 59000 units and have the KVA ratings of 50,100,150,200,300 and were mostly pole mounted transformers. Pad mounted were rated 500,750, and 100 KVA. Table 01 below show the total failure data for pole and pad mounted transformers [3].

Table 01. PMTs failure data in four different regions.

Region	T/D year	13.8 KV units		33 KV units	
		Pole mounted	Pad mounted	Pole mounted	Pad mounted
A	97	255	11	1005	13
B	67	206	2	416	3
C	39	549	38	817	15
D	13	113	1	6	0
%age of total failure for the selected voltage		95.57	4.43	98.64	1.36

The unsuitable (arc quenchless) circuit breaker is one of the main cause of the distribution transformers failure .This type of breakers not only itself burns but also damage the transformers. That's why it is recommended to use oil MCCB which can easily quench the transients during switching .The figure o2 below show the burnt circuit breaker.

Figure 02. Burnt circuit breaker

Over the last three years trends, it has been reported about 1150 transformer failures per year in Saudi Arabia [4]. Same is the case in United Kingdom where the failure rate is 100 out of 160,000 transformers .This failure is not only uneconomical but also creates unreliability in the country .

4. EXISTING PROTECTIONS:

Transformer is vitally important that there is at least a basic understanding of how transformer and their related electrical systems can be properly protected.

(a)-Over current protection.
(b)-Differential protection.
(c)-Gas actuated relay.
(d)-Over voltage protection.
(e)-Transient over voltage.

Figure 03. PMT near CC at MUET jomshoro

As most of the transformers burns due to overloading. This overloading can be easily handled by using circuit breakers on the primary side of the distribution transformer.

5. CIRCUIT BREAKERS

It is an automatically operated electrical switch which is designed to protect an electrical circuit from damage i.e. over loading or short circuit. The Breaker triggers automatically when it detects faulty condition. The breakers can be reset either manually or automatically to resume the normal operation .A circuit breaker gives protection from over current as well as isolation from energized circuit components and unenergized circuit components . The circuit breaker performs sensing and measurement of the over current [5];

Over currents are detected by three different devices;

a)Thermal Release for overloads:

This consists of bi-metallic strip which, if heated beyond the normal operating values, become deformed, releasing the lock which holds the contacts .The reaction time of the strip is inversely proportional to the intensity of the current. Due to its thermal inertia, the bi-metallic strip reacts faster when a second overload follows the first in quick succession.

b) Magnetic Release for short circuits:

This consists of magnetic loop whose effect releases the lock which hold the contacts , thus triggering the breaker if there is a high over current .T his response time is very short (around one tenth of a second)

c) Electronics Release for both:

A coil, placed on each conductor, continuously measure the current in each of them. This information is processed by the electronic module which controls the breakers tripping when the values of the setting are exceeded. The curve of the release shows three operating zones:

1) “Instantaneous” operating zone: This provide protection against high intensity short circuits .It is either set by construction at the fixed value usually from 5 to 20 KA and or adjustable according to the device .

2) “Short delay” operating zone: This give protection to the PMTs from lower intensity short circuits, which generally occurs at the end of the line .The trip threshold is generally adjustable. The time of the delay can be increased by threshold.

3)”Long delay” operating zone: Its characteristics are similar to the thermal release. It protects conductors against overloads.

The different operating zones are shown in the figure 04 below;

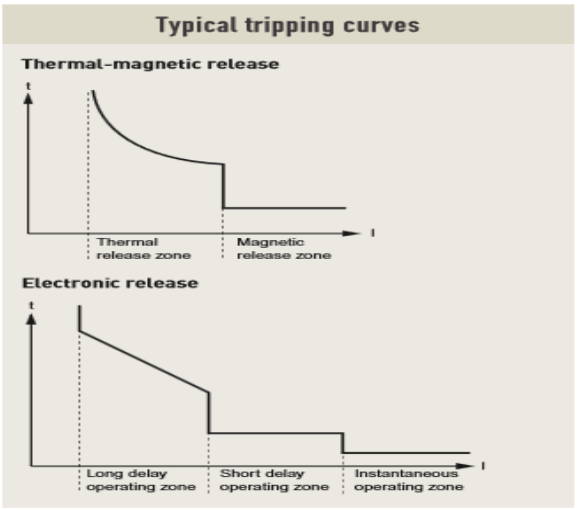


Figure 04. Tripping curves of the circuit breaker

6. ELECTRIC ARC

The circuit breaker has arc chamber which is designed to control the electric arc produced when the contacts open. The arc energy can become considerable, up to 100KJ and 20 k`c, and can cause the contacts to be melted. Therefore, it is required to extinguish the arc as quickly as possible, in order to limit its effects. The magnetic field produced of the arc (which is a conductor) is used to push arc into an arc chamber and extend it until it has been extinguished .The circuit breaker must have very fast opening mechanisms of the contacts (limiting erosion)and high contact pressure (opposition of the electrodynamics forces)[6] .The graph below shows the arc .

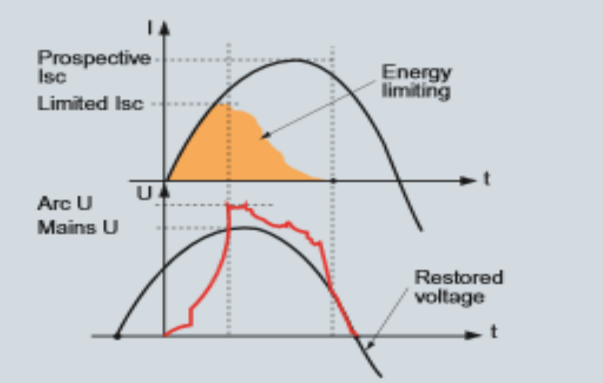


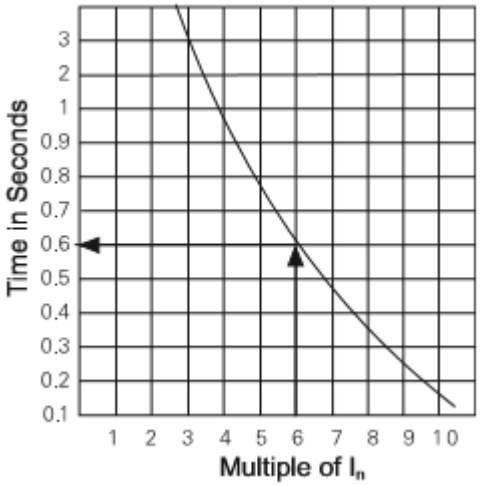
Figure 05. Arc graph

Further, MCCB is composed up of very fast switching mechanism, contact system, Arc extinguishing device and tripping unit, all contained in a compact molded case and core .The insulating case and cover are made of high strength, heat resistant, flame retardant resin bonded thermosetting materials which increased the safety of the operating personal The interesting and advance technique in the modern MCCB is that they have oil for quenching the arc produced during the switching of the circuit breaker [7]. Circuit breakers are installed in some countries on the transformers but because of their transients during switching, many transformers fails .So the small oil tank in MCCB prevents the transients .The secondary side normal current of the different ratings (KVA) transformers are shown in the table 02.when the current will increases from the rated current then MCCB will disconnect the loads from the transformer and thus failure will be avoided.

Table 02. Pole Mounted transformers ratings and their secondary currents.

S no	Rating (KVA)	V line (V)	I 2 (A)
1	50	400	72.08
2	100	400	144.33
3	200	400	288.67
4	250	400	360.84
5	300	400	433.01
6	400	400	577.35

The tripping time of the circuit breakers depend upon the amount of current that flow through the circuit breaker. Greater is the short circuit current, faster will be the disconnection. In the graph below, horizontal axis I e X- axes show multiple of the current and the vertical axis i.e. Y- axes show the time of tripping of the breaker in seconds. The graph show that when the abnormal current will be multiple of 6, the breaker will disconnect in 0.6 seconds .This has been shown in the figure below[8] ;



. **Figure 06.** Time verses current graph

So the circuit breaker is located between the transformer low voltage coil and low voltage bushings to provide protection against over loads and the secondary faults .A pole- mounted transformer with circuit breaker is shown in the figure below ;

Figure 07. PMTs with circuit breaker. SOURCE: visit to HESCO

The transients in the breaker during switching's are not controlled by these like breakers .But can be easily controlled by an oil MCCB in which the arc is quenched out by the oil.

7. CONCLUSION

It has been reported that a number of distribution transformer fails to work due to prolong over loading, single phase loading, unbalancing, power theft and hooking etc. All these results overloading e.g. more current flows through the transformer which results its heating and the heating cause failure of insulation i.e. failure of the distribution transformer . A large number of transformer failures occur per year in Pakistan especially in rural areas because of over loading which is not only uneconomical but also unreliable. It is important to provide automatic protection on low voltage side of distribution transformer to reduce the failure rate and save the economy. Its best solution is to use oil filled circuit breakers on the low voltage side of the pole mounted transformers. The failure due to circuit breakers transients (arc) can be easily controlled by the oil MCCB which has oil in a small tank inside the breaker to quench the arc and protect the transformer from the abnormal huge current i-e circuit breakers arc during the connecting and disconnecting of the bi-metallic strip. So the primary means of protecting distribution transformer is the circuit breakers i.e. oil MCCB which is designed to give adequate protection from the short circuit, severe over loadings and transients of the breaker during switching time. Within a portion of a second (depending on the current), the circuit breaker disconnect the transformer and prevent it from failure. So oil filled circuit breakers are recommended to install on the pole mounted transformers to prevent the failure of PMTs.

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