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Condition Monitoring of High Voltage Equipment

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Abstract

Electrical system network comprises of generation, transmission line and distribution substation. A power generated from the generation station will be transferred through transmission line to the distribution substation. It involved a lot of main components such as transformer. Transformer is used to regulate the voltage by stepping up a high voltage and low current to sustain the power transformer. In order to do this, the power transfer within primary and secondary windings of the transformer must be approximately equal for better transmission unless there is losses in the transformer. The losses in the transformer are non-load and load losses. Non-load losses are minor losses in the transformer because it not varies to the loading of the load. It is an internal reaction due to the magnetizing current that energized the core of the transformer which produced core losses, stray losses, hysteresis losses, stray eddy current and dielectric losses [1]. On the others hand, load losses are due to eddy current and heat losses. These two losses contributed a significant loss in the transformer due to friction and heat created from the resistance winding resulting the flow of the current that can breakdown dielectric strength of the insulating oil inside the transformer. The insulating oil is used as an insulation system consist three main properties such as electrical, chemical and physical properties. Hence, the insulation oil is said to be serviceability when all the criteria needed is fulfilled. Therefore, the criteria in dielectric strength of the insulating oil is tested using standard oil test equipment based on the setting of the breakdown voltage indicate there is no moisture content and conducting substances in the insulating oil. The insulating oils used in the transformer required periodically testing, hence it has created the baseline properties of the insulating oils that needs to be studied and the data obtained can provide a valuable information to overcome any cause or losses that shorten the life span of the transformer.

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I. INTRODUCTION

The dielectric strength and dielectric dissipation factor tests will be the main focused due to the load losses in the transformer. There are three main properties that will be tested in this study. The first property is the dielectric strength test where it will be conducted by applying voltage at the rate of 2 KV per seconds between two electrodes immersed in the insulating oils until the spark occurred [1]. If low value of voltage is detected, it means the dielectric strength of the insulating oils has been broken down due to the existing of the moisture and impurities properties inside the insulating oils. The electric dissipation factor test is concerned about the current leakage between the live source and grounded connected in the transformer when the insulating oils is placed between them. In the insulating oils there are two components exists which are capacitive or reactive and resistive or active, when the leakage current passed through it. The best ways to measure the existing of the resistivity in the insulating oils by using megger tester which directly showing the resistivity in ohms or mega-ohms. The insulating oils is said to be a good insulation when the value of the resistivity is high and poor insulation means low resistivity [1].

Then the last properties are a power factors of insulating oils which is determined from the cosine

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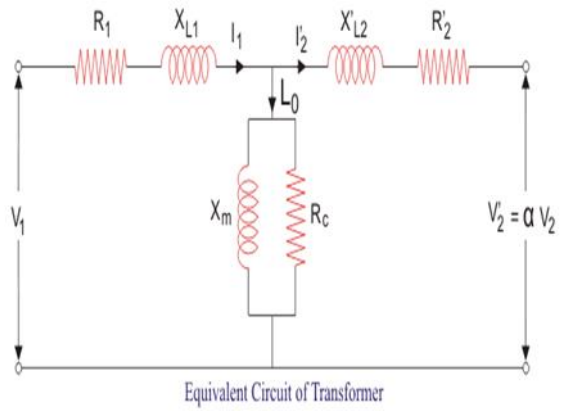
of phase angle between an ac voltage applied and the resulting current. The test on the power factor of the insulting oils are important to define the dielectric loss and dielectric heating. The losses and heating on the dielectric give a limitation of the power factor at 0.05% [2] measured from the room temperature in the range of 25°C to 27°C. If the power factors excess 0.5%, it required further analysis to determine the cause of high power factor and with the power factor at 2.0% the insulating oils need to be replaced.

II. MATERIALS AND METHODS

In any electrical equipment, the losses are the major cause of low efficiency on the performance of the equipment and if the losses getting higher in values, it will cause catastrophe. The transformer efficiency is rated at 95% to 99% and this efficiency is calculated from the output power over the input power plus losses. The percentage of the losses is in the range of 0.1% to 0.5% [2] and it can be formulated from the equivalent circuit on the primary side of the transformer as shown below.



Equivalent Circuit of Transformer

The above circuit show the resistances, inductances and capacitances that representing the losses in the transformer where most of the losses come from resistances because it produced power when the leakage current passed through it. The inductance and capacitor are only defined as mutual losses and they are ignored in the efficiency calculation. Assuming the output power at the secondary side is equal to the primary side than the power losses is at 0.5% when the efficiency is at 95% [2].

If the output power at secondary is not equal to the primary side, the power losses getting bigger and produced heat in the transformer and it will affect the insulating oils properties. Thus, the power losses are the main cause of the degrading factor for the insulating oils that works as the protection inside the transformer. Therefore, it is important to keep the insulating oil in good condition so that it can sink out the heat produced from the losses in the transformer.

This study is focused on the on-line monitor condition for the insulating oils inside the transformer. The on-line monitoring is expected to detect the degrading factors of the insulating oils during operation and hence, define the cause and come out with the seemly solution. From the study, the cause of the degrading factors is from the dielectric strength, dielectric dissipation factors and dielectric losses in the insulating oils. The method approached for the on-line monitoring is by applying a device to detect the frequency and temperature of the insulating oils and made a comparison with the modelling of the physical components representing the degrading factors.

For example, during operation the insulating oils will produced a spectrum of frequencies than these frequencies will be matched with the modelling of the physical components through the simulation process. From the results obtained, the comparison with the off-line testing will take place for identification for the cause of degrading in the insulating oils. This identification is important to make sure that the correct frequency related to the correct degrading factors for the insulating oils. Once the cause has been identified, the possible solution will be introduced such as providing advance warning of developing condition for the insulating oils inside the transformer.

The insulating oils test conducting by using oil test equipment is used to measure the breakdown voltage of the dielectric strength and if the dielectric strength is low the insulating oils needs to be

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replaced. This is a normal practice for the insulating oils used in the transformer and the measurement for the insulating oils is taken during off-line condition. Therefore, this study is intended to change this approach to an on-line condition where the insulating oils is monitoring during the operation and any problems occurred will be detected earlier and with the advance warning of developing condition the losses in the transformer can be minimized.

III. DISCUSSION

Conducting an insulating oils testing is simple task to perform because the oil test equipment is a latest equipment with laptop connection for displaying a data being tested. The data will be analyzed and model as a physical component. From here the suitable modelling is developed so that the design of the physical components will be designed properly and if the model of the physical components is poor then the performance of the physical components may not improve and the design is useless.

The challenges for modelling the physical components are depending on the distinction between physical components with models and also different modelling with different operational ranges. The distinction between physical components with the models must be defined clearly because it representing the existing of the real things or condition from the data collection and it come with different operational ranges. Therefore, a different insulating oils will be modelled with different operation ranges. Furthermore, the physical components will be applied with a various physical law to develop mathematical equation to represent the model. The mathematical equation is used to describe the model and it comes with varieties of equations and many forms such as linear equations or nonlinear equation and many more. Hence, the analyses can be carried out from the mathematical equation to perform quantitative along with qualitative analyses.

The next task in this study is to perform an on-line testing for the insulating oils based on the existing of the frequency and temperature during operation. Between these two parameters, the frequency is hard to detect because it sensed together with the vibration or harmonic from the transformer during operation. While the temperature is less complicated than frequency. A specific device will be developed to detect the frequency and temperature of the insulating oils at the time of operation and compared it with the off-line testing. Hence, a direct comparison data can be made to verify results to enhance further investigation.

IV. CONCLUSION

It started with the insulating oils being tested periodically using oil test equipment and a data collection from the tests will be studied for breakdown voltage level for the insulating oils. The breakdown voltage level graph indicated a degradation factors which are from the moisture and impurities properties [3] and it can be modelled as the capacitive and inductive components before the mathematical equation is set up for the modelling. The model is used to tune the parameters of these two components so that they are close enough to these properties. Then the data simulation and data measurement will be analyzed for data comparison.

In dielectric dissipation factor, the physical components such as capacitive and resistive has been defined where the physical components are used as the insulator to the insulation oils and then a current will be injected to these components so that the measurement can be taken at the point the current leaking occurred. The data will be collected for the comparison. The dielectric losses of the insulation oils can be determined from the measurement of voltage and current which gives the limitation of the power factor rated at 0.05% [3] per room temperature. The power factor is measured when the temperature rises up to the point where the value of the power factor reached 0.5%, so that the physical component in the transformer can be modelled as inductive or capacitive components.

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The modelling of the physical components which responded to the frequency is an advantage to determine the frequency response of the insulating oils. The frequency obtained will be compared with frequency from the insulating oils during operation. The frequency may be changes in many forms and it required a good filtering method to get a right frequency for the insulating oils.

Lastly, temperatures are measurement and by using the same principle before where the measurement will be taken during off-line and on-line testing. The comparison is made to determine at what point the breakdown level for the dielectric strength in the insulating oils.

REFERENCES

[1]. E. Tuncer, Y. V. Serdyuk, and S. M. Gubanski, “Dielectric Mixtures: Electrical Properties and Modeling”, IEEE Transformer Electrical Insulation.

[2]. Franzén, and S. Karlsson, “Failure modes and effects analysis of transformers,” Royal Institute of Technology, KTH School of Electrical Engineering, Stockholm, Sweden.

[3]. F. Ten, M. A. R. M. Fernando, Z. D. Wang, “Dielectric Properties Measurements of Transformer Oil, Paper and Pressboard with the Effect of Moisture and Ageing,” IEEE Annual Report Conference on Electrical Insulation and Dielectric Phenomena