Study of THD in Distribution Transformer

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Abstract— Transformers are the interface between the supply and the load. The presence of non-linear loads injects voltage and current harmonics. The harmonics caused by highly non-linear devices degrade the performance of transformers. The harmonic power losses cause additional heating in power system components and increased operational costs. These harmonics can cause excessive loss and abnormal temperature rise in the transformers, thus reducing the performance. The life span of the transformer supplying non-linear loads deteriorates and reduces the lifetime. There is a need to reduce the unwanted effects of harmonic components in non-linear loads. An attempt is made in this paper to study the THD of distribution transformers supplying variety of nonlinear load. The distribution transformers of different ratings have been simulated and the result indicating the THD with change in the reactive power is illustrated. The simulation results also reveals that an increase in the current harmonic distortion increases the transformer losses and has bearing on its life expectancy.=

Keywords— Total harmonic distortion, non-linear loads, distribution transformer, linear-loads, losses.

1 Introduction

Transformers play an important role of power transfer in power system. The transformers are designed considering frequency, perfect sinusoidal load current and balanced supply voltage. As the population is increasing the demand for reliable and quality power is increasing simultaneously. Hence, the non-linear loads are increasing on the system for better comforts.

Under linear conditions, the current is only produced by the fundamental component, but under non-linear conditions, the current contains fundamental and harmonic components of higher order. As the harmonic components of the current become more significant, the THD increases. As a result, the amount of current flowing through the transformer increases the temperature. As the THD increases, the temperature of the transformer also increases; hence, the insulation of the transformer deteriorates and potentially reduces its lifetime. The increase in temperature also reduces the power factor, efficiency and capacity of the transformer. To study the situation, the simulation is done for the distribution transformers using MATLAB/SIMULINK.

2 Simulation of Distribution Transformer:

The distribution transformer of rating 25 kVA , 11KV/433V connected in delta star configuration is connected to the dynamic load and the simulation is shown in figure 1.

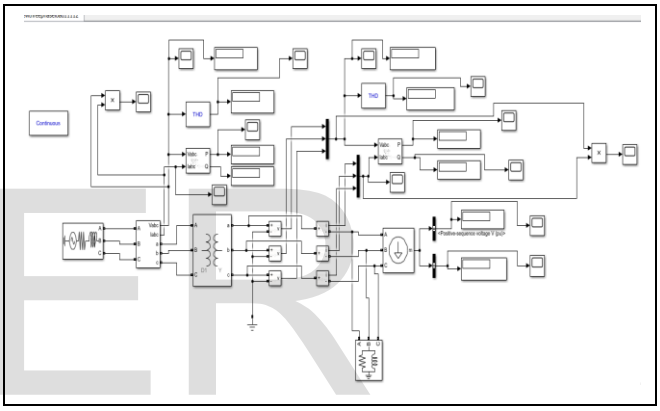

Fig. 1. Simulation of distribution transformer

The results of the simulation are as shown in the succeeding figures.

2.1. Simulation Results and Discussions

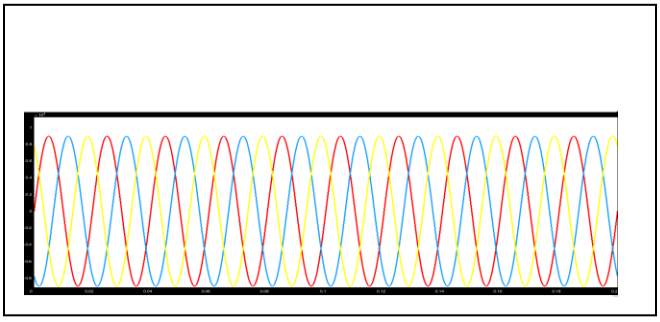

Fig. 2. Figure 2: Input voltage waveform

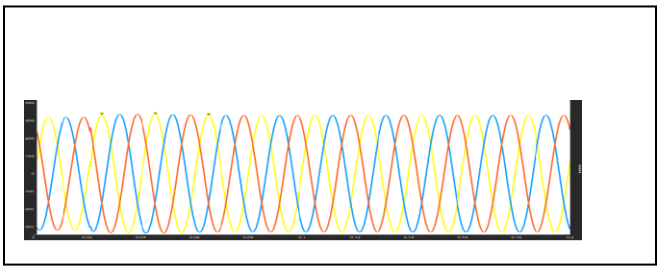

Figure 3: Output voltage waveform

3. THD OF 25KVA TRANSFORMER

THD analysis is done for a transformer rating of 25kVA, supplying RL load which is connected in parallel to the dynamic load. The reactive power is varied and THD obtained is tabulated in Table 1.

Sl no	Reactive Power (Var)	THD at the Input side	THD at the Output side
1	0Var	2.885e-02	4.449e-02
2	500Var	3.102e-02	4.652e-02
3	1KVar	3.225e-02	4.834e-02

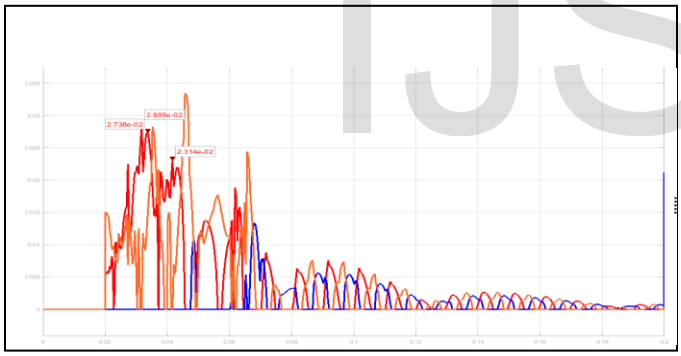

Fig 4: THD of voltage on input side of the transformer

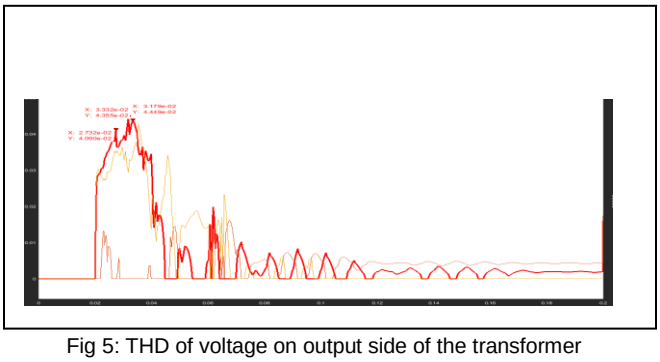

Fig 5: THD of voltage on output side of the transformer

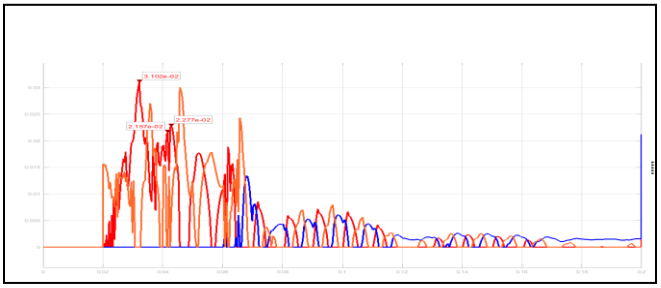

Fig 6: THD of voltage at the input side of the transformer when load is varied at 500VAR

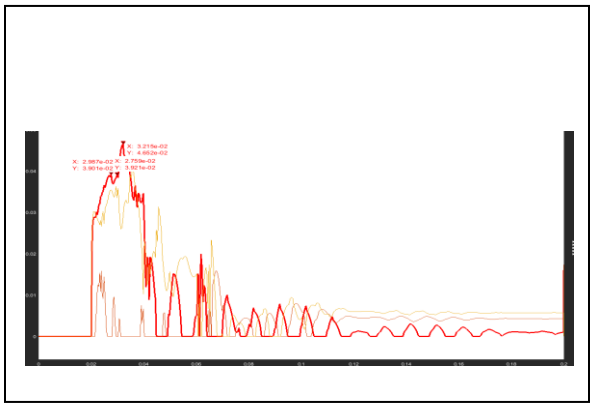

Fig 7: THD of voltage at the output side of the transformer when load is varied at 500VAR

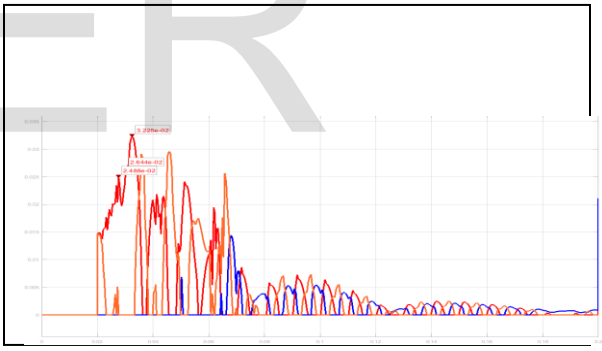

Fig 8: THD of voltage on input side of the transformer when load is varied at 1000VAR

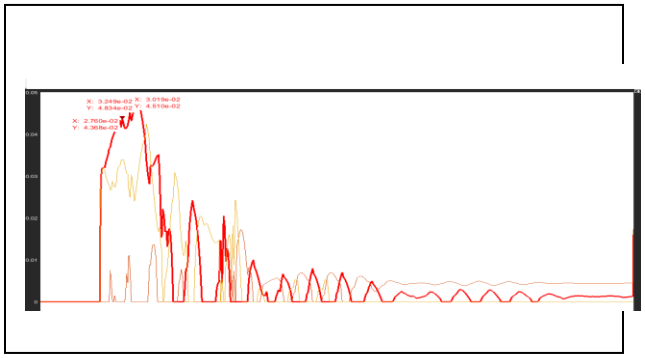

Fig 9: THD of voltage on output side of the transformer when load is varied at 1000VAR

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THD of 25kVA transformer with varied reactive power

Sl no	Reactive Power (Var)	THD at the Input side	THD at the Output side
1	0Var	2.885e-02	4.449e-02
2	500Var	3.102e-02	4.652e-02
3	1KVar	3.225e-02	4.834e-02

The change in THD is depicted in the Graph as shown in below figure :-

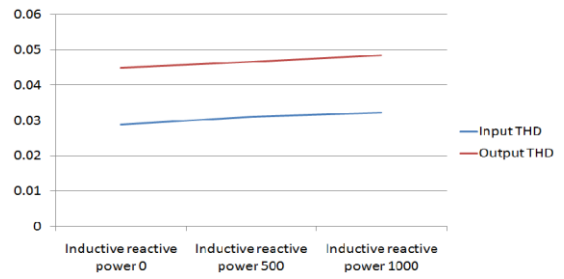

Fig 10: Plot of Input side THD and Output side THD for varied inductive loads of 25kVA transformer.

The simulation is carried out by giving the rating as 33kva to the transformer as similarly performed to the rating of a 25kva transformer and obtained the results by varying the reactive power of the inductive loads .

THD of 33kVA transformer with varied reactive power

Sl no	Reactive Power (Var)	THD at the Input side	THD at the Output side
1	0Var	3.059e-02	4.450e-02
2	500Var	3.233e-02	4.645e-02
3	1KVar	3.260e-02	4.719e-02

The change in THD is depicted in the Graph as shown in below figure :-

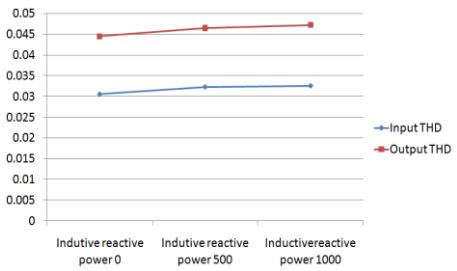

Fig 11: Plot of Input side THD and Output side THD for varied inductiveloads of 33kVA transformer.

4. SIMULATION WITH NON LINEAR LOAD:

The distribution transformer of rating 25 kVA , 11KV/400V connected in delta star configuration is connected to the non-linear load and the simulation is shown in below figure .

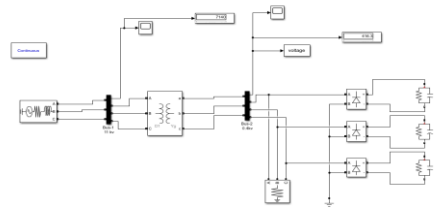

Fig 12: Simulation of distribution transformer connected to non-linear loads.

The results of the simulation are as shown in the succeeding figures.

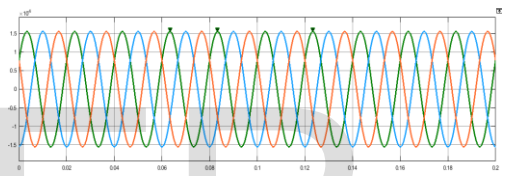

Fig 13: Input voltage waveform

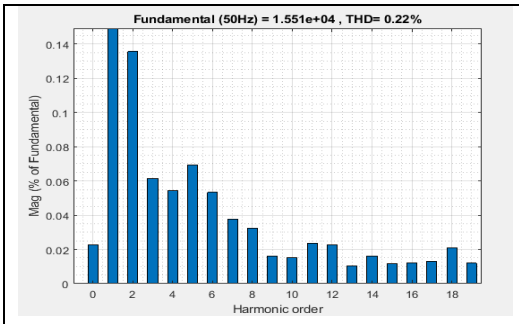

Fig 14: THD at the input side of the transformer

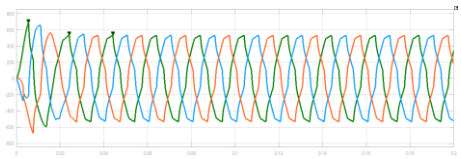

Fig 15: Output voltage waveform

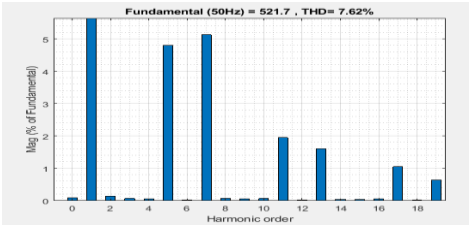

Fig 16: THD at the output side of the transformer.

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5. Conclusion

A 25 KVA and 33 KVA distribution transformers when supplying the linear loads do not exhibit power quality problems as the THD is well within the specified range. In contrary, when the load is nonlinear, the presence of harmonic components is quite considerable to pay the attention. As the THD increases the temperature of the transformer increases. This is quite evident from the simulation results. To mitigate the effect of harmonics due to nonlinear loads, it is necessary to suppress the predominant harmonic components using suitable filter circuit to ensure safe operation of the transformer and quality of the power.

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