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A REVIEW ON HARMONIC CURRENT AND VOLTAGE ANALYSIS IN TRANSFORMER FOR LOSS DIMINUTION

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ABSTRACT

Harmonics appear in electrical power system with such non-liner loads as electrical are furnaces, welding units, adjustable speed drives, accelerated aging of insulation, decrease in reliability of electrical power system Besides, harmonic voltage is also rising according to the rising of harmonic current. Harmonic current and voltage may basis (cause) rising of loss in receiving power transformers. However, systematic analysis of the loss of receiving power transformers has not been studied. The authors has been tried to analyze the relationship between loss in receiving transformers and harmonics. In this paper presents the studies of harmonics and inrush current in transformer for loss diminution.

KEYWORDS: transformer, harmonics, copper loss, iron loss, loss decline.

INTRODUCTION

In recent years, harmonic in power system has increased substantially due to the increasing of non linear load. With the present of nonlinear load, transformer leads to higher losses and reduction of the useful life. The increased losses due to harmonic distortion can cause excessive winding loss and abnormal temperature rise [8]. If the transformer cannot be operated up to its standard lifetime expectancy, economic loss will incur [2]. As non-sinusoidal harmonics have been generated from many sources,harmonicsflow through many Transformers and cause a compound effect to the power system [10].

LITERATURE REVIEW

The recent work carried out in the area of reduction of harmonics and inrush current to saving the energy of the transformer.Zainab nadhem abbas-al mausaoy in et. [1]Analysis, simulations, and design conducted is given to study, investigation and economical solution for harmonic current.

Li Qi Prony [4] investigation the harmonic selective active filters for power quality improvement. Unlike existing harmonic selective active filters, which require previous knowledge of harmonics and have limited reference generation ability for exponential decay in harmonics, the Prony analysis based active filters can identify frequencies, magnitudes, phases and even damping factors of harmonics. The dominant harmonics identified from Prony analysis are used for the harmonic reference generation for the harmonic selective active filters for power quality perfection.

Cao Wende; Li Shiqing; Xiong Nan; Li Jiufu in et. [9] Investigate Harmonic distortion power of the three definitions were carried out detailed analysis, and based on the data monitored from an enterprise's high frequency welding machine.

C. L. Cheng, S. C. Chern, Q. S. Chen, F. Y. Lin in [10] investigate the A flux analysis of three-phase transformer for inrush current.

TRANSFORMER LOSSES

Transformers are designed to deliver the required power to the connected loads with minimum losses at fundamental frequency. Transformer losses are generally classified into no load losses and load losses

P_T = total loss, watt,
P_{NL} = no load loss, watt
P_{LL} = load loss, watt

The no load loss or excitation loss are the losses due to the voltage excitation of the core and magnetic hysteresis and eddy currents. The load loss or impedance loss is subdivided into I^2R loss and stray loss caused by electromagnetic flux in the windings, core, core clamps, and magnetic shield, enclosure or

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tanks walls [8]. Thus, the total stray loss is subdivided into winding stray loss and stray loss in components other than the windings (P_{OSL}). The windings stray loss includes winding conductor strand loss and loss due to circulating currents between strands or parallel winding circuits. The total load loss can be stated as follows:

$$P_{LL} = P_{I2R} + P_{EC} + P_{OSL}$$

where,

P_{I2R} = loss in the winding
P_{EC} = eddy current loss
P_{OSL} = other stray loss

Fig.1Transformer equivalent T-circuit

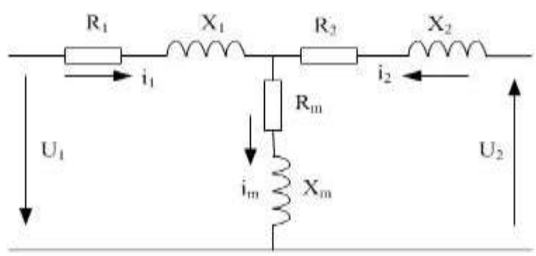
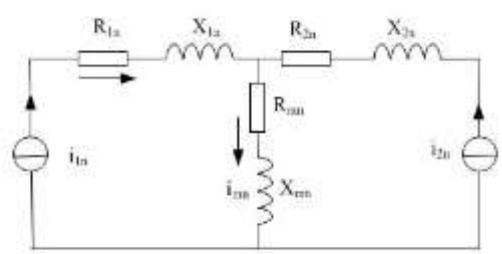


Fig2.Transformer n^th harmonic equivalent T-circuit



HARMONIC LOSS FACTOR

Harmonic loss factor, F_{HL} is a key indicator of the current harmonic impact on the winding eddy loss and other stray loss. The harmonic loss factor is normalized to either the fundamental or the rms current. F_{HL} for winding eddy current is the ratio of the total eddy current losses due to the harmonics, to the eddy current losses at the power frequency. The FHL-STR is the ratio of the other stray loss due to the harmonic to the other stray loss at power frequency. The eddy current loss is increased by a factor of F_{HL} and the other stray loss are increased by a factor of FHL-STR in the presence of harmonics [8].

TRANSFORMER HARMONIC MODEL

For harmonic equivalent circuit of the transformer, taking into consideration of the general harmonic sources are current sources, and with the harmonic number increases, the equivalent resistance change because of skin effect. The nth harmonic of the transformer equivalent circuit [9] as shown in figure 1.

TABLE.1 Harmonic data (Amplitude)

	phase	H1	H5	H7	H11	H13	H17	H19
CURRENT	A	616	145	77	128	55	21	8
	B	615	143	72	133	53	17	10
	C	600	131	46	130	45	14	8
VOLTAGE	A	25	10	7	16	7	4	1
	B	225	10	7	15	8	3	2
	C	225	9	5	17	7	3	2

TABLE.2 Harmonic data (Phase to angle)

	phase	H1	H5	H7	H11	H13	H17	H19
CURRENT	A	345	357	272	149	359	73	276
	B	226	118	133	261	234	203	152
	C	108	237	25	28	108	319	9
VOLTAGE	A	6	254	166	48	248	224	159
	B	240	18	24	161	123	100	34
	C	120	133	277	284	359	205	250

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TABLE.4 Transformer’s harmonic loss

harmonic	1	2	3	4	5	6	7	8
I_2 (A)	3015	8	11	11	149	15	43	14
I_2'(A)	12.2	0.3	0.4	0.4	6	0.6	1.7	0.6
Loss W	-	0.6	1.1	1.2	219.1	2.3	19.3	2.
Harmonic	99	10	11	12	13	14	15	total
I_2 (A)	23	9	148	17	58	10	7	-
I_2'(A)	0.9	0.4	5.9	0.7	2.3	0.4	0.3	-
Loss w	5.8	0.9	253.9	3.4	41.2	1.3	0.6	552.7

HARMONIC POWER ESTIMATE

The estimate of harmonic misrepresentation power mainly considers harmonic current Losses on other equipment. In succeeding calculations, we will focus on the harmonic distortion power of a high frequency welding factory and analyse the loss of harmonic current flow through other equipment, and this data is very important to the company that wants to summarize the advantage of harmonic handling [9].

Cao Wende, Li Shiqing, Xiong Nan, Li Jiufu says in [9] Harmonic distortion power of the three definitions were carried out detailed analysis, and based on the data monitored from an enterprise’s high frequency welding machine, the harmonic distortion power is calculated and analyzed

In the case authors for an enterprise that one 630KVA transformer with two high frequency welding machine as its load the parameter of transformer and high frequency are as follows:

Transformer: S_N630KVA, U_N10KV, U_N 0.4KV, P 810W, P 6200W;

HARMONIC CHARACTERISTICS

Ahsan h .Choudhary [12] investigates the harmonic characteristics of transformer excitation current under no-sinusoidal supply voltage. Author’s conduct a large numbers of simulations, with a wide variation in harmonics characteristics in the supply voltage.

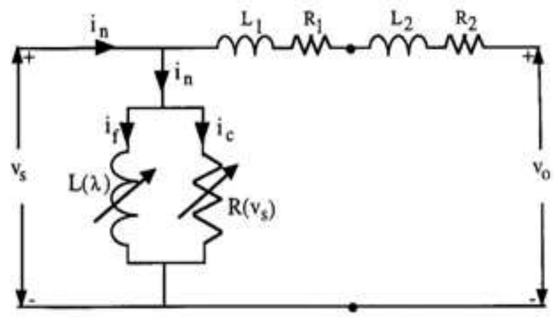

Fig.5.circuit model for an unloaded single phase

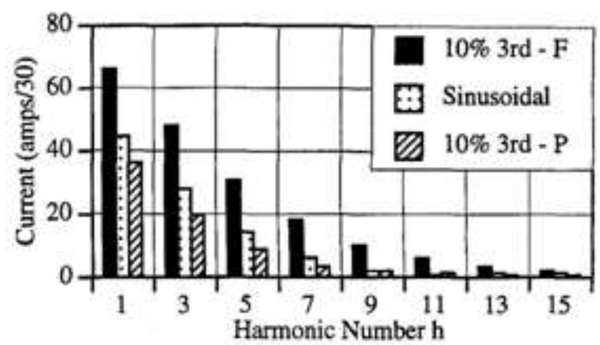

Fig.6 Effect of supply voltage on individual current harmonics

ACTIVE SUPPRESSION METHOD

C. L. Cheng, S. C. Chern, Q. S. Chen, F. Y. Lin used an active suppression method to estimate the transformer inrush current under harmonic sources. The suppression method is very simple and efficient. The flux of transformers is controlled to non-saturation by developed method. Non-sinusoidal excitation strongly influences the flux variation of three-phase transformers [10]. Authors in [10] a flux analysis of three-phase transformers for inrush current under non-sinusoidal excitation is anticipated. The maximum flux value of three-phase transformers is calculated and discussed. The results can be applied to improve the protective relaying system of three-phase transformers [10].

POWER SYSTEM REAL-TIME SIMULATOR

Hirohito Funato, Chiharu Sasaki, Yuki Chiku, and Satoshi Ogasawara said in et [6] the losses of receiving transformers caused by harmonic voltage and current were measured under different conditions to make

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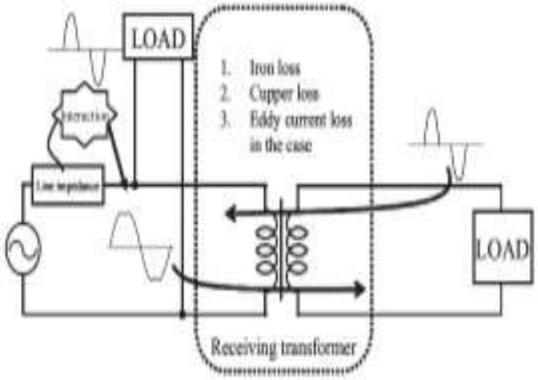
known the loss generation mechanism. The measurements were completed for real-scale (20 kVA) receiving transformers under different conditions. In order to evaluate transformer losses at real-scale power, a new power system real-time simulator was developed. Author's tried to investigate relation between loss in receiving transformer and harmonics [6].

Fig.2. Problem caused by harmonic current and voltage



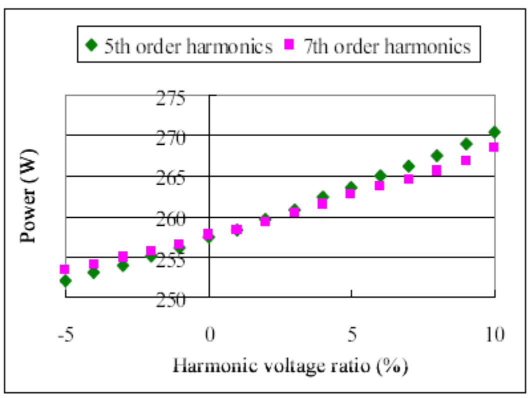


Fig3.Relation between harmonic voltage and transformer loss (20 kva)

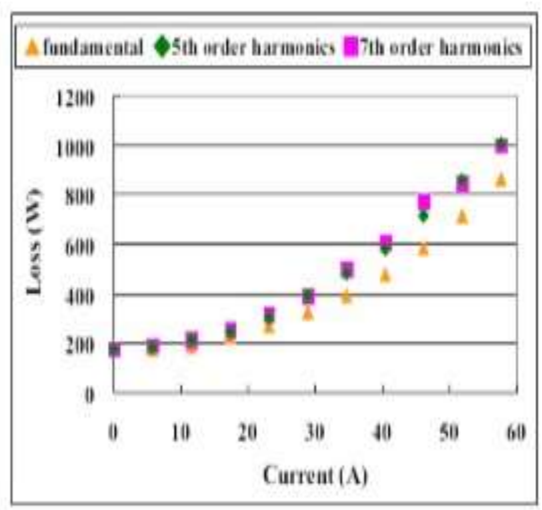
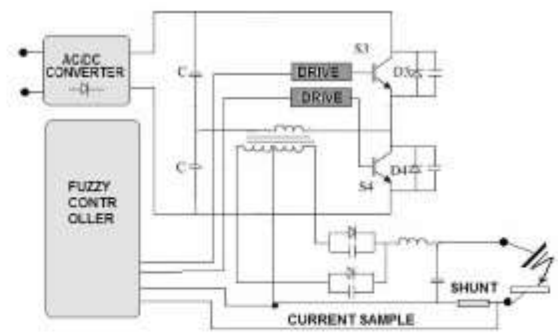


Fig4.Relation between harmonic current and transformer loss (170 V)

WELDING CURRENT CONTROL

Mohammad Jafari in et. [11] Introduce a new Fuzzy Controlled Welding Machine (FCWM). The Fuzzy controller is applied to the welding machine to improve some problems of welding process. The overall scheme of FCWM is shown in fig 6[11].

Fig.6 Overall scheme of FCWM



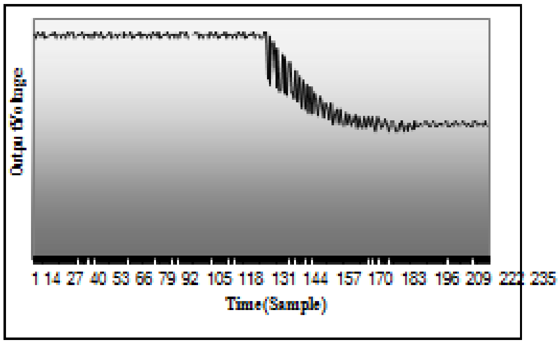


Fig.7 output voltage variation during weld

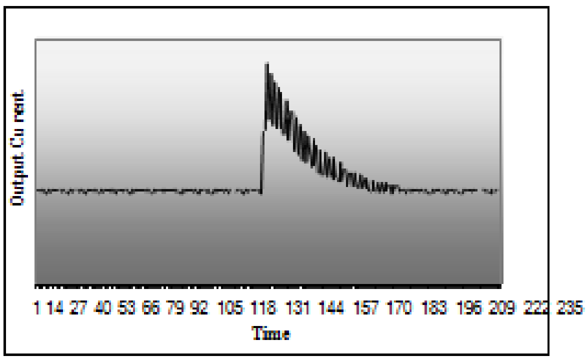


Fig.7 output current variation during welding

CONCLUSION

Harmonics are the big issue in electrical power system. This paper introduces harmonic investigation of transformer and methods to estimates the voltage and current harmonics, reduction in power loss which results save in electrical energy.

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