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INVESTIGATION AND ANALYSIS OF HARMONICS IN WELDING TRANSFORMER

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ABSTRACT

The power quality deterioration has been significantly increased in the recent past due to the harmonics introduced by variable frequency derives and non-linear loads. Welding transformer with irregular duty cycle has a major contribution in increases the THD level. This paper presented the analysis of relationship between loss in welding transformer and harmonics. Under over rated units in welding works plays prime role in loss component and excess of inrush current drawn by the welding transformer. Selection of appropriate unit rating for welding works significant simultaneously control the sudden increases and drawn of load current and fruitful in transient suppression. Real time approach of investigation deviation much from simulation one. The experimental results on different ratings unit before and after treatment have been investigated, and effect of improvement in the performances during both standby and welding period has been recorded. Power quality analysis of welding business for harmonic distortion has been carried out using power quality analyser.

KEYWORDS: Welding Transformer, Harmonic Analysis, Inrush Current, Power Quality Clamp meter, Real Time Measurement

INTRODUCTION

Interharmonics 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. Interharmonics level is regulated by European standard EN 50160 within the limits of 0.1-0.2% [20]. For the welding works the suitable voltage level varies from 15- 46 volt and current range 200-600 A. The welding transformer specified deigned to have output voltage to the required for initiation arc. In case of using DC supply in welding works the rectifier unit introduced DC harmonics. There may also be a filter choke (inductor) to smooth the DC Current. The entire Transformer and rectifier assembly may be called a Transformer or welder, but "Welding power supply" would be more appropriate term. A Transformer style Welding power supply converts the high Voltage and low Current electricity from the utility mains into a low voltage and high current, usually between 17 to 45 volts and 55 to 590 amps. A rectifier converts the AC into DC on more expensive machines. This design typically allows the welder to select the output Current by variously moving a primary winding closer or farther from a secondary winding, moving a magnetic shunt in and out of the core of the Transformer, using a series saturating reactor with a variable saturating technique in series with the secondary Current output, or by simply permitting the welder to select the output Voltage from a set of taps on the Transformer's secondary winding.

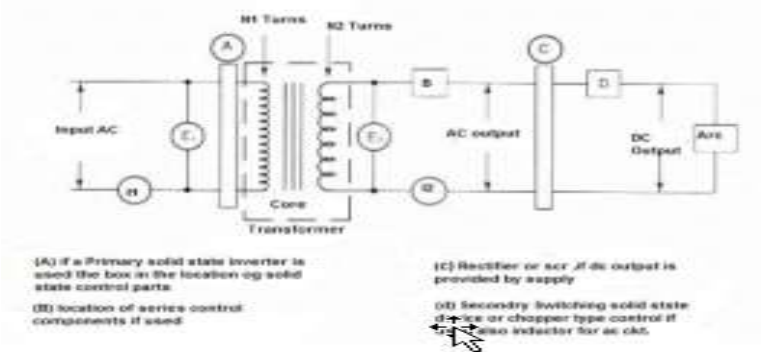

Fig. 1 Principal Electrical Element of a Welding Transformer

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HARMONICS

Harmonic Currents and Voltages are formed by non-linear loads connected on the power distribution system. Harmonic misrepresentation is a form of pollution in the electric plants that can basis problems if the sum of the harmonic Currents increases above certain limits.

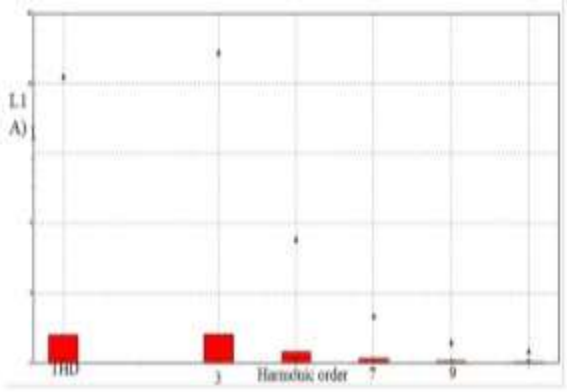

Fig 2 Harmonic Orders

All power electronic converters used in different types of electronic systems can increase harmonic disturbances by injecting harmonic Currents directly into the grid. An unadulterated voltage and sine wave has no misrepresentation and no harmonics but non-sinusoidal wave has distortion and harmonics. Harmonic distortion is measured in terms of total harmonic distortion (THD).

TABLE: 1 HARMONIC FREQUENCY

Harmonic order	**Frequencies**
Fundamental	50 HZ
3rd Harmonic	150 HZ
5th Harmonic	250 HZ
7th Harmonic	350 HZ
9th Harmonic	450 HZ
11th Harmonic	550 HZ
13th Harmonic	650 HZ
15th Harmonic	750 HZ

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Current Harmonics
These important bridge rectifier circuits produce Current harmonics. Current Harmonics do have an effect on the electrical equipment supplying harmonic Current to the device (Transformers, conductors). Current Harmonics can cause issues with distribution equipment with has to handle the Current from the utility Transformer all the way down to the device, but generally don't affect other equipment connected to the electrical system. Harmonic Currents can cause excessive heating to Transformers. For electrical systems feeding single phase loads the third harmonic has gained attention in design consideration and Transformer selection for causing the neutral conductor to draw excessive Current.

Voltage Harmonics
Voltage Harmonics can affect sensitive equipment throughout your facility. Voltage Harmonics arise when Current Harmonics are able to create sags in the Voltage supply. When any device draws Current it creates a Voltage dip which is required for Current to flow.

Harmonics in Transformer
In addition to the operation of Transformers on the sinusoidal supplies, the harmonic behaviour becomes important as the size and rating of the Transformer increases.

Causes harmonic Currents are-
1. Additional copper losses due to harmonic Currents
2. Increased core losses
3. Increased electromagnetic interference with communication circuits.

Causes harmonic voltage are-
1. Increased dielectric stress on insulation
2. Electro static interference with communication circuits.
3. Resonance between winding reactance and feeder capacitance

Inrush Current
Inrush current, input surge current or switch on surge refers to maximum instantaneous input current drawn by electric device when first turned on.

Transformers may draw several times their normal full-load Current when first energized, for a few cycles of the input waveform.

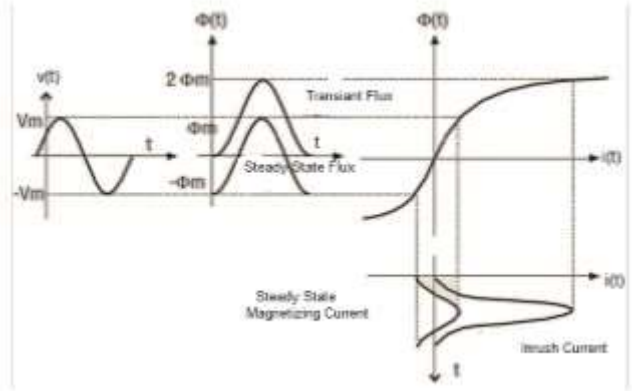

Fig.3 Graphical Description of the Inrush Current Phenomenon

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Total Harmonic Distortion (THD)
THD is the distortion of the relationship between line powers and load Current drawn. Utilities typically supply Voltages with less than 2% THD. However, the Current THD for electronic devices may be over 100%. The THD in voltage is represented by THD_V and in that of current it is represented by THD_I [1].

$$THD_V=\sqrt{V_2^2+V_3^2+V_4^2+V_5^2}/V_1 *100\%$$

$$THD_I=\sqrt{I_2^2+I_3^2+I_4^2+I_5^2}/I_1 *100\%$$

Total harmonic distortion is shown in table 3 with the help of power quality clamp meter, we measured the THD_V and THD_I at welding time for all four single phase welding transformer. Voltage and current at welding time also recorded for all four welding transformer

TOOL USED 345 POWER QUALITY CLAMP METER

Fig 4.Power Quality Clamp Meter

It is a rugged, accurate, professional power industry tool for measuring Current, Voltage, power quality, input and output waveforms of current and voltage with harmonics with recording facility.

INVESTIGATIONAL CONSEQUENCE

The Harmonic pattern of single phase Welding Transformer at Standby and at Welding was obtained along with their Current and Voltage Waveform. The data collected was used in Harmonic analysis. The Harmonics of Welding Transformer was recorded with the help of power quality clamp meter. The Experiment was carried out on 04 Welding Transformer with different ratings. The Experimental setup is as follows-

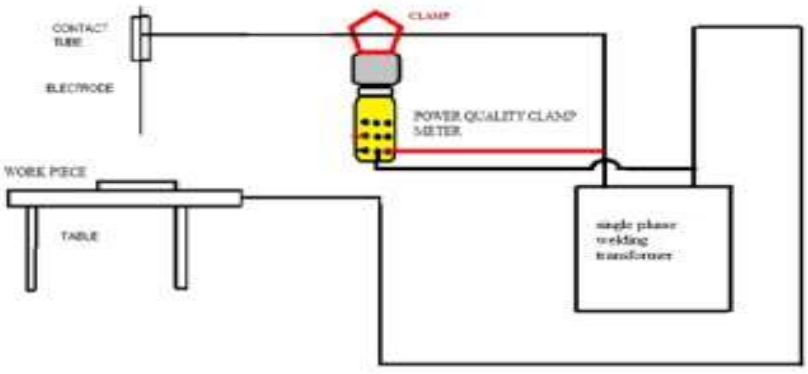

Fig.5 Experimental Circuit

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RESULTS AND DISCUSSIONS

The Experiment was carried out on 04 single phase welding Transformer of different ratings. The following experimental results were obtained. First of all we take the reading when Transformer at standby and Measured all the Parameter like open circuit Voltage, leakage Current and Harmonics presents in Voltage. After then we take the reading when Transformer on load that means at welding time and measured all the Parameter Voltage, Current, THDI, THDV, Power factor, and efficiency in welding time of each Transformer.

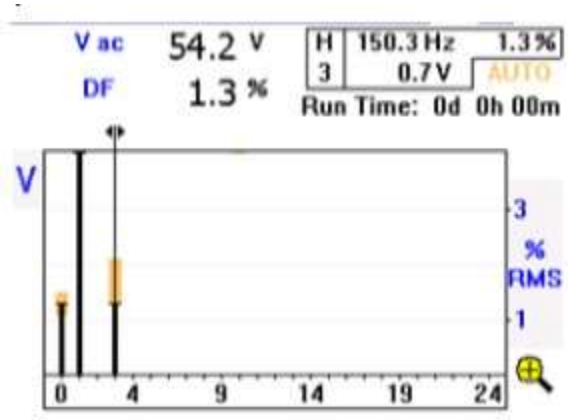

Fig.6 Harmonic occur in Voltage at Stand by

Fig.7 Power at Standby

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Table2. Measured Parameter on Standby

S.NO	O.C.V	I_0	W	VA	VAR	PF	Harmonics occurs
T1 3 KVA	54	0.13	5.29	29.9	29.4	0.17	3rd (0.3 V)
T2 3.5 KVA	50	0.10	5.30	23	22.3	0.23	3rd (0.3 V), 5th (0.5 V)
T3 4 KVA	55	0.15	5.42	34.5	34.3	0.15	3rd (0.7 V)
T4 4.5 KVA	60	0.08	5.29	18.8	17.6	0.28	3rd (0.6 V)

Table 2 shows the value of all parameter of tested transformer and which harmonic occur at the time of standby also shows. We can see that 3rd harmonic resent when transformer is on standby.

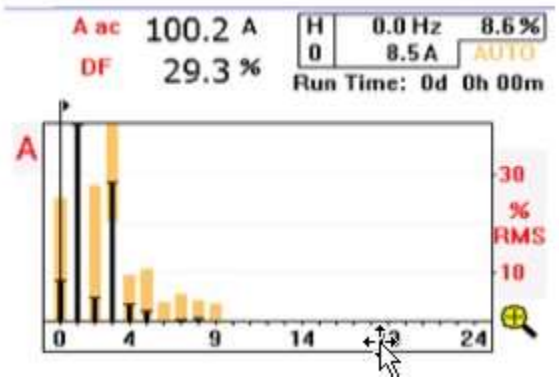

Fig.8 Voltage harmonic at welding time

Order of harmonics in voltage at welding time is measured we can see as a snap shot in fig 8.voltage is step down from 230 to 22.30 volt. Distortion factor is 19.6%.

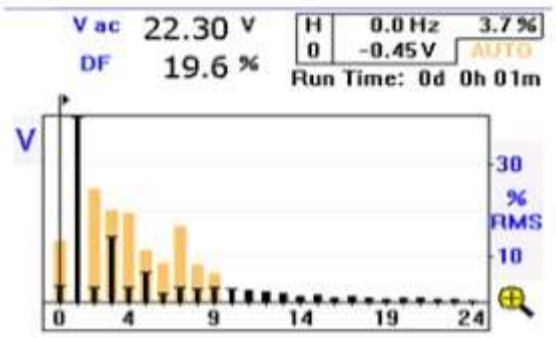

Fig.9 Fig.8 Current harmonic at welding time

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Order of harmonics in current at welding time shown in fig 9.we can see that distortion factor is 29% and current is step up to 100 A, that's why we called current transformer because in welding transformer current is step up. Voltage is step down from 230 volt to 22 volt.

Table3. Working Measured Value at Welding of 60% duty cycle

S.NO	W	VA	VAR	THDv	THDi	V	I
T1 3 KVA	2189	2548	1304	1.2%	5%	19.46	130.9
T2 3.5 KVA	2150	2590	1444	3.0%	0.3%	25.99	133.5
T3 4 KVA	2226	2711	1547	90%	10%	24.07	131.2
T4 4.5 KVA	3020	3750	2223	4.5%	0.9%	29.27	128.1

Table 4 Measured values after using Capacitor different VAR of test Transformer

C(VAR)	W	VA	VAR	COSφ	V	I	THD(i)	THD(v)	Total Loss	η
300 VAR	2189	2406	1000	0.90	19.46	125	2.0%	0.1%	520 W	80.8%
500 VAR	2189	2330	800	0.93	19.46	121	1.8%	0.08%	500 W	81.0%
600 VAR	2189	2298	700	0.95	19.46	118	1.5%	0.05%	440 W	83.2%

Table 4 shown the all measured parameter after using the Filter of different VAR values and we saw that Efficiency of welding transformer increased.

CONCLUSION

In this paper harmonic investigation of welding Transformer were carried out for energy efficiency and Harmonics of different rating Transformer is investigated. It was found that in welding Transformer Harmonics occurs at standby in Voltage generally 3rd Harmonic occurs. And at welding time there are large Harmonics presents in Voltage and Current. On the other hand since welding machine are non-linear loads they introduce Harmonics in the supply system, since it has pitiable Power factor it draws more power with large Harmonic Currents. To reduce Harmonics generated

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by welding machine, suitable Capacitor of proper kvar rating is used. With its used much enhancement in distortion level was observed. Power factor improved from 0.85 to 0.90. THDV and THDI, was improved which means that the suggested remedy was successful in reducing Harmonics thereby improving energy efficiency up to 2% of welding machine under test by using considerable kvar.

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