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Design of Chokeless Welding Transformer With load Series Motor

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Abstract: ***The Forced air cooled welding transformers are conventionally provided with fractional horse power single phase motor of shaded pole type. The fan starts running as soon as the transformer is switched on. Generally, welding transformer are designed for a maximum duty cycle of 60%. The exhaust fan goes on running at a constant speed even when no welding work is in progress or only small currents are drawn from the machine.***
We thought of designing a simple exhaust fan which would run in proportion to the welding work, and would stop automatically when no welding work is going on. This led to the development of a load series motor.
Because of the choke size and cost of transformer is increased. To reduce this size and cost choke is replaced with one coil.

Keywords: Chockeless Transformer, Welding Transformer, Electrical Arc Welding.

Introduction

Welding is the most efficient way to join metal. It is only way to join metal to make them acts as a one piece. A step down transformer with open circuit voltage of about 70 volts and negative voltage characteristics can be used for welding work. To get the negative voltage characteristics Choke is used. It is an inductive reactance is concern with secondary circuit.

It is step down transformer having Choke with tap in between primary control the arc current and give it stability include in welding transformer. It is observed that the welding transformer with Choke is having large size. To reduce the size of welding transformer Choke is replaced by one coil. This coil function same as Choke. These coil reduce size as well as cost of the welding transformer.

The ordinary welding transformer has forced air cooled transformer consist of an exhaust fan which rotates at a constant speed whether welding work is going or not. Therefore the more energy will be wasted there. To avoid the waste of energy here the load series motor is used.

The load series motor which is to be connected in series with load. ordinary exhaust fan is replaced by load series motor.

It is observed that the welding transformer with choke or movable core is having large size, so to reduce the size we are replacing the choke with one coil. This coil functions same as the choke. This coil helps to reduce the size as well as the cost of the welding transformer.

The forced air cooled transformer consists of an exhaust fan which rotates at a constant speed whether the welding work is going or not. So that, the more energy will be wasted there. To avoid this, the load series motor is used. The load series motor as the name suggests is a motor which is to be connected in series with a load. . The load series motor which is a shaded pole motor but designed in such a way that if connected in series with load, it will run and speed of such motor will be proportional to the load current. The ordinary exhaust fan motor can be easily replaced by the load series motor proportional to the load current.[2]

Here is the comparison of two different types of welding transformers

Electric Arc Welding:

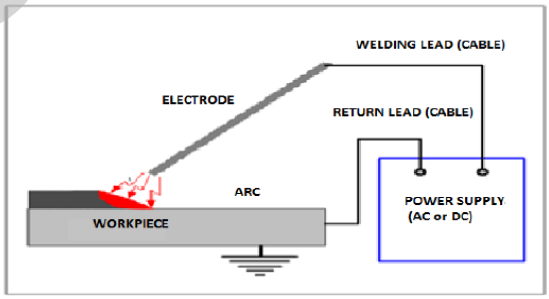

Fig.:1 Electrical Arc Welding

If the ends of the two wires of an electric circuit (of suitable voltage and ampere either A.C. or D.C.) are brought together and then slowly withdrawn, a spark will be produced across the ends; this is the basis principle of the arc welding process. The spark (known as an arc) has a temperature of about 3600°C(6500F) and being concentrated in a melt metal instantly.

If one end of the circuit is attached to a piece of metal (i.e. the work) and the other to a pointed rod of carbon, the carbon does not melt although in time it gradually burns away and has to be replaced.

If a metal rod or wire (termed an electrode) is used instead of the carbon, the heat of arc will melt both the work and the tip of the electrode, the molten metal from the latter mixing with that of the former.

This remark presumes that the current is sufficiently high and that the gap between the work and electrode tip is not

too great. A very important feature of the metal arc is that the tiny globules of molten metal are forced across the arc, and do not fall by gravity. This characteristic which enables the process to be used for overheat welding.

The heat in this type of welding is obtained from an arc struck between an electrode and the metal to be welded, as shown in fig.

In addition to the fusion, of metals at the joint the process involves the provision of a filler metal, i.e. Additional metal necessary to fill in and complete the joint. The arc welding is widely used for joining of metal parts instead of bolting or riveting, the repair of fractured casting and filling in by the deposition of new metal, of worn parts.

The electrode employed may be either of carbon or of metal, giving rise to the carbon arc and metallic arc process. In the former the current supplied must be D.C. but in the latter it may be either D.C. or A.C. The length of the arc is generally between one or two times of the diameter of electrode. The voltage across the arc to produce a good weld should be between 20 and 30.

Welding Transformer:

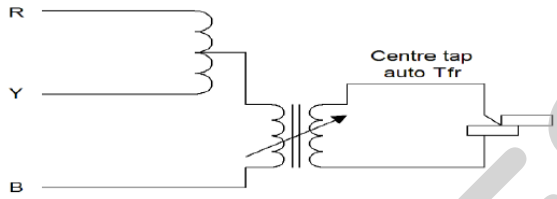

Fig.no.2 Three Phase Welding Transformer

Welding Transformers are used in AC machines to change alternating current from the power line into a low-voltage, high amperage current in the secondary winding. A combination of primary and/or secondary taps on the welding transformer are commonly used to provide a macro adjustment of the welding current, as well as adjustment of secondary voltage. Transformer ratings for AC machines are expressed in KVA (kilovolt-amperes) for a specified duty cycle. This duty cycle rating is a thermal rating, and indicates the amount of energy that the transformer can deliver for a stated percentage of a specific time period, usually one minute, without exceeding its temperature rating. The RMS Short Circuit Secondary Current specification indicates the maximum current that can be obtained from the transformer. Since heating is a function of the welding current, this parameter gives an indication of the thickness of the materials that can be welded.

A step down transformer with open circuit voltage of about 70 volts and having negative voltage characteristic can be used for welding work. To get the negative voltage characteristics a choke are used i.e. an inductive reactance is concern with secondary circuit. Another definition is a step down transformer having choke with taps or movable core in between primary control the arc current and to give it stability comprises a „welding transformer.

Welding transformer may be single phase, two phase, or current two phase and three phase supply transformers are used. They are used for thicker welding plates. Transformer may be oil cooled or air cooled. Big transformers are always oil cooled. Transformer may be AC or DC generator and generator may be oil/gas operated. Current range (AC welding transformer) -600 amp. Open circuit voltage 70v-100v. Basically two types of the power source can be used for arc welding machine purpose that is AC transformer and DC generator rectifier. Power source consists of the two cables, electrode cables and earthling clamps; electrode holder stringer and electrode or rod

There are two methods to obtain a single phase power from three phase AC supply with minimum unbalance.

Method No.1

In this method there are two transformers, one is center tap auto transformer and other is a step down double wound transformer.

The center tap of two phase lines by an auto transformer, and the third phase is directly connected to give approximately 381V of a 440V 3 phase AC supply to the primary of the step down transformer.

This type of welding transformer has a movable core in between the primary and secondary coils, which diverts the flux through it to control arc current.

The primary current in the 2 phase, lines is half of the current in the third phase. Such transformers are wound for any capacity small and big much vibrations are produced due to movable core, causing wear and tear and thus reducing the life if not fitted and handled properly the step less current variation can be obtained to adjust for particular job.

Method No. 2

In this type, 3 limbed core there are 2 primaries and 2 secondary's housed on each other on the outer two limbs of core. The central limb is without any winding on.

The primaries are connected in open delta type as shown in Fig. No. Each primary coil is designed for 440V.A separate choke either of step less controlled type i.e. with movable core or of stopped controlled type is used to control arc current. Such types are wound for any capacity as transformer.

Working of Chokeless welding transformer with load series motor:

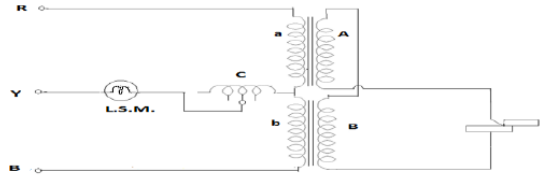

Fig no. 3 Working diagram of Chokeless transformer.

Chokeless welding transformer witad series motor is a core type transformer, in which coils are form wound and are of cylindrical type. The round or cylindrical coils are wound in such a way as to fit over a cruciform core section.

will be insulated from the other with the help of materials like paper, cloth and so on. The general arrangement of the core-type transformer with respect to the core is shown below. Both low-voltage (LV) and high voltage (HV) windings are shown in above figure. In ordinary welding transformer, either a separate choke is required to be provided to control the arc current or a separate auto transformer or the step to be provided to control the arc current or a separate auto transformer or the step down transformer with movable core is required to be provided. Because of this the size of the welding transformer becomes large. To overcome this, a tapped coil is inserted in the central limb of core. That is coil „c". The size of core required for this is slightly bigger than the original three limbed core. The turns of this coil is taken as 36.6% of the other two coils.

Vector representation of Chokeless Transformer:

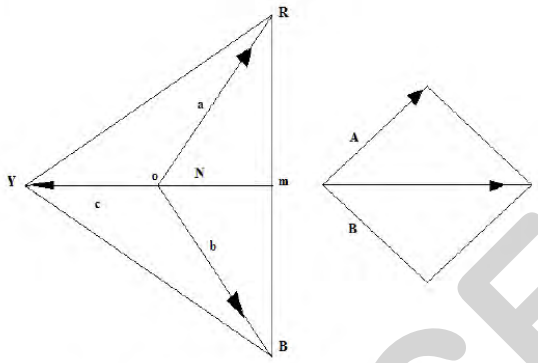

Fig. No. 4 Vector Diagram of chokeless transformer

It is observed that if, the turns of this newly inserted coil is, taken 36.6% of the other two primary coils then with its taps, by varying the secondary voltage the arc can be varied. a and b are two primary coils designed for 400/440v. „c" is a coil with taps, which can be connected to supply through multi-way rotary switches to get the required current range. This coil is having 36.6% turns of, a and b.

As the coil c has the 36.6% turns the point 0 will not be N- the center of triangle RYB. Now if some load is applied on the secondary then the voltage across the two coils a and b will decrease and that across c will increase. The point 0 will shift towards the base of the triangle RYB.

If the secondary load is increased then again the voltage across a and b drops, across c increases. The point 0 shifts further towards the base RB of the triangle RYB. And as the voltage across a & b drops (its phase angle also changes) the secondary voltage too drops. The drop in a secondary voltage is more than proportionate because of the change in phase angle, thus the required negative voltage or drooping characteristics can be obtained.

The load series motor is single phase motor to be connected in series with the load is a current controlled shaded pole motor, designed in such a way that if connected in series with the load, it will run and the speed of such a motor will proportional to the load current that is arc current. This special motor is very suitable for forced air cooled welding transformer. The ordinary exhaust fan can be very easily replaced by the load series motor.

Design of Welding Transformer:[3]

The design of transformers depends upon the ratings, voltages, type, service conditions, and the relative costs of copper, iron, insulating materials, labor, machinery and organization.

Welding transformer is essential an step down transformer with a fixed standard primary-input voltage 230/250 volts for single phase unites and 400/440 volts for double phase or three phase units. The secondary voltage being 50/60 to 100 volts depending upon the service condition and the work for which it is to be used.

Core frames are standardized to reduce the manufacturing costs. Preliminary designs are prepared on the basis of previous experience, with due regard to the economical use of materials. Thus, dimensions may have to be modified in order to avoid wastage of large quantities of sheet steel or to conform to the transport loading gauge. In service, any transformer is subject to electrical, thermal and mechanical stresses.

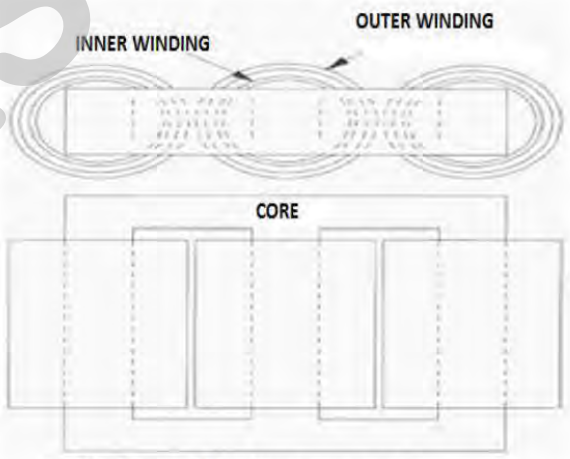

Fig No. 5 Assembly of core type transformer

Abbreviation:
Øm = Main flux (Wb)
Bm = Maximum flux density ($Wb/m2$)
δ = Current density(ampere/$m2$)
Ai = Net window area ($m2$)
D = Distance between core centers(m)
d = Diameter of circumscribed circle round core (m)
Kw = Space factor for window.
f = Frequency(Hz)
Aw = Area of window(m2)
Ww = Width of window(m)
Hw = Height of window(m)

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Core Design :

Assumption:

Bm for CRGO 1.4 to 1.7T

Current density=2.2 to 4 A/mm^2

For three phase welding transformers value of
Kt = 0.6 to 0.7

For square core transformer value of k = 0.45

Window Space factor
Kw is 8/30
Higher KV = 8/30+6 = 0.22

Specification:

Voltage rating = 440V
Current rating = 250A
General duty cycle = 60%
Current density = 5-10A/$mm2$
Flux density, For C.R.N.G.O. grade = 1.3-1.5 Wb/$m2$
Type of cooling = Air forced
Supply = Three phase-400/440V,50Hz
OC voltage = 50/60/70 volts
Power factor = 0.96
Wattage = 40 W
Poles = 4 pole
Frequency = 50Hz
Speed = 1500 RPM

Design Calculation:

d=0.06m
d=(Ai/k)1/2
where Ai =d2*k
Ai = (0.06)2*0.45 = 1.62*10-3
Aw = Q/ 3.33*f*Ai* δ *Bm*Kw*10-3
Aw = 6/ 3.33*50*1.62*10-3*3.2*106*1.6*0.22*10-3
Aw = 0.0197482m2
Hw/Ww =3
Aw = Hw*Ww = 3*Ww2
Ww = (Aw/3)1/2= 0.081134m
Hw = 3*Ww = 0.2434m
Wc = Kt*d = 0.6*0.06 = 0.036m
H= Hw+2Wc = 0.2434+0.072 = 0.3154m
H = 31.54cm
L/Ww = 2 to 4
Assume L/Ww = 2.4
L = 2.4*Ww = 2.4*0.0811 = 0.1946m
L = 19.46cm

Calculation For efficiency
KVA Ratings = 6 KVA
Input Voltage = 415 V
Output Voltage = 50 V
I1= KVA Rating/ Input Voltage
I1 = 6000/415 = 14.45 Amp
I2 = KVA Rating/ Output Voltage
I2= 6000/50 = 120 Amp
Input Power = V*I*cosØ
Consider Power factor = 0.9
Input Power = 415*14.45*0.9 = 5397.075
Output Power = 50*120*0.8 = 4800
Total losses= 5397.075-4800 = 597.075
Efficiency = KVA ratings/ KVA ratings + Total losses
= 6000/6000+597.075 = 90.95%

Calculation of diameter of wire

Types Of Guage	Measured Reading (mm)	No. of Revolution 1(rev)=0.5	Diameter without insulation(mm)	Diameter with insulation (mm)
12 SWG	0.14	5*0.5=2.5	2.64	3.30
10 SWG	0.26	7*0.5=3.5	3.76	4.82
3 SWG	0.58	11*0.5=5.5	6.08	6.50

Table No. 1 Diameter of wire

Calculation of primary winding
For first & third limb
Height 9cm=90mm/3.30mm=27.27
1 Layer=27 turns

Coil	1	2	3	4	5	6	7	8	9	10
P1	27	26.5	26.5	26	25.5	25	24.5	25	24	24.5
P2	25.5	25.5	25.5	24.5	24	25	24	24.5	24	24

Table No. 2 Value of Primary Winding

Calculation of primary winding
1 layer = 18.75 turns
Calculated primary turn = 254 turns
Height 9cm = 90 mm/ 4.82 mm = 18.75 turns
Middle limb turn = 254 * 40 / 100 = 101.6 turn
Primary winding 40% turn
With insulation = 4.82 mm

Coil	1	2	3
P1	19	20	19
P2	19	20	19

Table No. 3 Value of Primary Winding

Calculation of secondary winding
For first & third limb
Height 9cm = 90mm/6.50mm = 13.84 turns
1 Layer = 14turns

Coil	1	2	3	4
S1	14	13	14	13
S2	13	14	13	14

Table No. 4 Value of Primary Winding

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Results:

4 way switch position	6 way switch position	Line Voltage	Load Current
1	1	398	14.5
	2	399	15
	3	400	15.3
	4	400	15.6
	5	402	16
	6	403	16.4
2	1	404	17
	2	405	18
	3	405	19
	4	406	19.5
	5	406	20
	6	407	21
3	1	408	22
	2	408	23
	3	409	23.5
	4	409	24
	5	410	25
	6	410	25.4
4	1	411	27
	2	411	28
	3	412	29
	4	412	30
	5	412	30.5
	6	413	31

Table No. 5 Results

Future Scope:

In our project work experiment has been carried out, in that small industry & we arrive at important conclusion by using Chokeless Transformer for industrial application energy has been save as well as improvement efficiency. Important aspects is this Chokeless Transformer is most economical for industry purpose.

In future scope application, we are going to implement for such applications,

1. Ship building industries
2. Pipes and penstock joining
3. Construction work
4. Building industries
5. Automobile and aircraft industries
6. Boiler, chemical, fertilizer industries

Conclusion:

We consider overall performance the machine is very useful in small scale as well as big industries. As the cost of this welding machine is nearly 50%-60% less than the ordinary three phase welding transformer. The overall energy conservation is more. Also the size of the machine is reduced.

We are getting very useful information about design of load series motor and the welding machine. Some further modification can also be done in order to achieve better performance, efficiency and regulation. So that, the use of Chokeless Welding Transformer with load series motor, is advantageous and convenient.

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