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Design, Manufacturing and Testing of Multiuser Three Phase Welding Machine

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Abstract - Welding is a fabrication or sculptural process that joins materials, usually metals or thermoplastics, by causing fusion, which is distinct from lower temperature metal-joining techniques such as brazing and soldering, which do not melt the base metal. In addition to melting the base metal, a filler material is often added to the joint to form a pool of molten material (the weld pool) that cools to form a joint that can be as strong, or even stronger, than the base material. Pressure may also be used in conjunction with heat, or by itself, to produce a weld. All the welding machines are 1phase and 2phase in nature and only one user can work on one machine, no other one user can work on same machine. If we use another holder for welding then we should use another welding machine, so it will increase cost of machine, it takes some space, energy use, so, by using three phase welding machine we can overcome this problem. In three phase welding machine we use three holders at a time for low and medium work and for heavy work we can use two holders at a time.

***Key Words*: Welding, Welding Transformer , winding, electrical energy , Frequency**

1.INTRODUCTION *(Size 11 , cambria font)*

Welding is a fabrication or sculptural process that joins materials, usually metals or thermoplastics, by causing fusion, which is distinct from lower temperature metal-joining techniques such as brazing and soldering, which do not melt the base metal. Although less common, there are also solid-state welding processes such as friction welding or shielded active gas welding in which metal does not melt.
Some of the best-known welding methods include:
Shielded metal arc welding (SMAW) – also known as "stick welding or electric welding", uses an electrode that has flux around it to protect the weld puddle. The electrode holderholds the electrode as it slowly melts away. Slag protects the weld puddle from atmospheric contamination.

i) Gas tungsten arc welding (GTAW) – also known as TIG (tungsten, inert gas), uses a non-consumable tungsten electrode to produce the weld. The weld area is protected from atmospheric contamination by an inert shielding gas such as argon or helium.

ii) Gas metal arc welding (GMAW) – commonly termed MIG (metal, inert gas), uses a wire feeding gun that feeds wire at an adjustable speed and flows an argon-based shielding gas or a mix of argon and carbon dioxide (CO_2) over the weld puddle to protect it from atmospheric contamination.

iii) Flux-cored arc welding (FCAW) – almost identical to MIG welding except it uses a special tubular wire filled with flux; it can be used with or without shielding gas, depending on the filler.

iv) Submerged arc welding (SAW) – uses an automatically fed consumable electrode and a blanket of granular fusible flux. The molten weld and the arc zone are protected from atmospheric contamination by being "submerged" under the flux blanket.

v) Electroslag welding (ESW) – a highly productive, single pass welding process for thicker materials between 1 inch (25 mm) and 12 inches (300 mm) in a vertical or close to vertical position.

2. METHODOLOGY

2.1 Design Aspects of Welding Transformer

The design of transformer depends upon the ratings, voltage, type, service conditions, and the relative costs of copper, iron, insulating materials, labor, machinery and organization. Welding transformer is essentially a step-down transformer with a fixed standard primary input voltage 230/250 volts for single phase units and 400/440 volts for double phase or three phase units. The secondary voltage being 50/60 to 100 volts depending on the service condition and the work for which it is to be used.
Core frames are standardized to reduce the manufacturing cost. 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.

ϕ m = Main flux. Wb.
Bm = maximum flux density. Wb/m2.
ɗ = Current density, amperes/m2.
Ai = net core section, m2.
Aw = net window area, m2.
L = Core length, m.
D = Distance between core centers, m.
d = diameter of circumscribed circle round core.
kw = Space factor for window.
f = frequency C/S.
Et = e.m.f. per turn. Volts.
T1, T2 = number of primary and secondary turns
I1, I2 = primary and secondary currents, amperes.
V1, V2 = primary and secondary voltage, volts.
a1, a2 = primary secondary conductor section, m2.

With a current density in both primary and secondary windings, the copper area in one window, for a three-phase transformer is-

$$2\,(a1T1 + a2T2) = Kw\ Aw.$$

Now, as a1T1 = a2T2

Primary current I1 = a1 ɗ= Kw
Aw ɗ /AT1

So that for ampere turns of primary or secondary

IT = I1T1 = I2T2 = ¼ Kw Aw ɗ

The rating in volt ampere is,

S = 3 V1 I1,
= 3 V1/T1 = I1T1 =3Et IT
= 3 4.44 f Bm Ai 1/4 Kw Aw ɗ
= 3.33 of Aw Ai Bm ɗ Kw…. (A)

And in case of single-phase core type transformer (or shell type) the active window area is,

(a1T1 + a2T2) = Kw Aw.

So that the output becomes

S = 2.22 f Ai Aw Bm ɗ Kw …. (B)

This basis for design can be related comparatively simply to the emf per turn. Since the flux ϕ m determines the core section the ampere turns IT fix the total copper area, the ratio ϕ m / IT = r will be constant for a transformer of a given type, service and method of construction. The output in KWA per phase is,

$$S = 4.44\ f\ \phi\ m\ T,\ I * 10^3$$
$$= 4.44\ (\phi\ m^2/r)\ 10^3$$
$$\phi\ m = \sqrt{}\ (r.10^3/4.44\ f$$

Substituting this value of ϕ m in the expression for Et,

$$Et = 4.44\ f\ \phi\ m$$
$$= 4.44\ f\ \sqrt{}\ s.\ \sqrt{}\ (r.10^3/4.44\ f)$$
$$= K\ \sqrt{}\ s$$

Where $K = \sqrt{}\ (4.44\ f\ r.10^3)$

This value of K depends on type, material labour, costs, factory organization, etc. the ratio r does not change with size, in a range of K approximately is

(a) For three phase welding transformer – 0.5 to 0.7
(b) For single phase welding transformers
  i) Shell type = 1 to 1.2
  ii) Core type = 0.75 to 0.85

With this a workable design can now be built on a basis of experience. Choosing Bm and the product Ai Aw is known from equation (A) or (B) Et from equation (C) and appropriate value of Ai can be calculated from Et and chosen value of Bm. The core is design ed to conform to a standard frame, from which d and D are obtained. The length L of the window between core circumscribing circle.

The net core area is 0.9 times the gross area for 10 percent loss of area in plate insulation. The values of Bm and □ depend on the quality of core material and winding material respectively. Generally, for welding transformer the Bm is taken as 1 Wb/m^2 dynamo grade type laminations 1.2 Wb/m^2 for cold rolled non-grain-oriented type.

The current density is taken in between 5 and 10 Amps/sq.mm depending on the duty cycle for which it is to be designed. Duty cycle is more criterion which generally is not taken in to account while designing other transformers but should be taken in to account while designing welding transformer viz some welding transformers are designed for 60% duty cycle, some for 35%, duty cycle or for 20% duty cycle too.

3 ϕ welding machine, 20 kva, 440 volt / 60 volt.

2.2 Primary circuit

The primary circuit was design to vary in current selection without tempering with the coil itself.it has a four-step coil with three looping for the selection of current capacity.

The primary winding is star connected. In primary circuit the winding has total 175 turns for 240volts.the winding begins at the start point S and was given 160 turns with an aluminum wire of size gauge 11. The first tap was introduced after the first winding and was labeled A, the winding continues with same size gauge for another 5 turns before the second tap labeled B. The third tap C and the last winding labeled E was given 5 turns each with same size wire gauge 11.

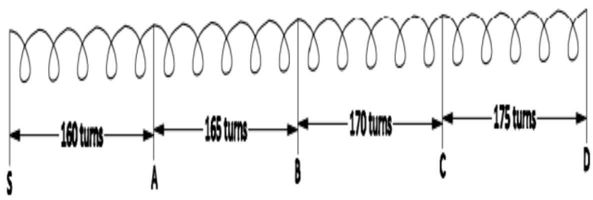

Fig.1 Primary winding

2.3 The Secondary Circuit

The secondary winding is star connected. In secondary circuit the winding has total 23 turns for 33volts.the winding begins at the start point S and end with C an aluminum wire of size gauge 3.

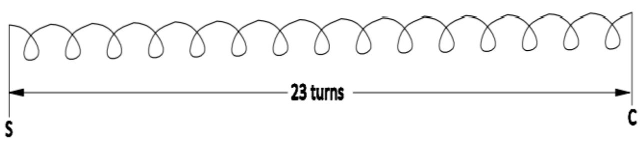

Fig.2 Secondary winding

Table 1: showing the primary voltage and primary turn values.

Primary voltage (star connection)	Primary turn
240 volts	160 turns
245 volts	165 turns
250 volts	170 turns
260 volts	175 turns

Table 2: showing the secondary voltage and load secondary turn values.

Secondary voltage (star connection)	Secondary turn
34 volts	23 turns

2.4 Coil Specification

Table 3: showing the primary and secondary coil specifications values.

	Primary Winding	Secondary Winding
Wire Gauge	11 Gauge	3 Gauge
Coil Height	80 mm	50 mm
Coil width	40 mm	30 mm
Coil Weight	5.5 kg	3 kg
Coil Winding	Aluminum	Aluminum

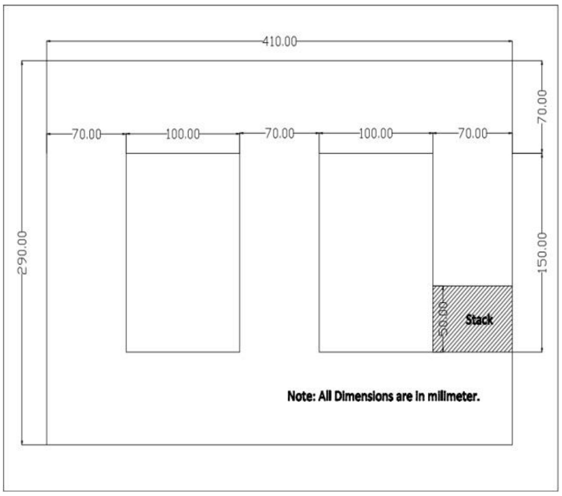

Fig.3 Three phase core

2.5 Core

The core is made of laminations assembled to provide a continuous magnetic path with a minimum of air gap included. The lamination steel help to minimize eddy current loss and the thickness of the lamination varies from 0.35 mm for a frequency of 50Hz 0.5 mm for frequency of 25Hz.The cores are in the form of long strips. L's, E's and I shapes as shown below

Table 4: showing the laminated core strip and weight calculation values.

Core strip	Core Weight
70 * 220 (mm)	34 kg
70 * 170 (mm)	18 kg
70 * 270 (mm)	14 kg
Total	66 kg

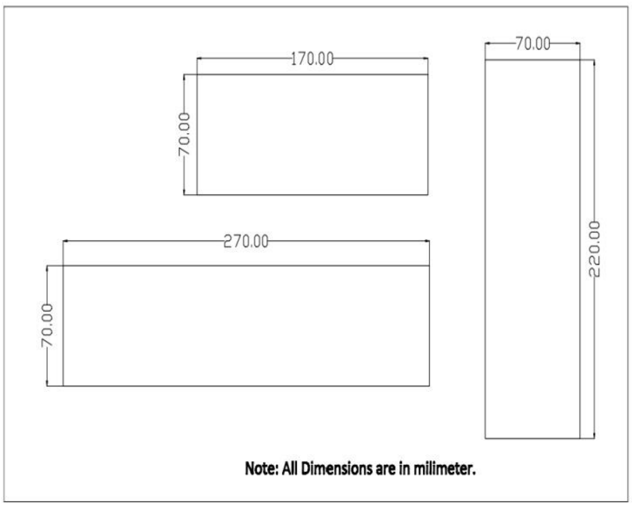

Fig.4 Laminated core

i) **Aluminum as Coil**

Aluminum wire is of more advantages in winding process. It is easy to winding. It has less weight compared to copper. low tensile strength. Most advantage is, it has low cost compared to copper and easily available in market. The current density used for aluminum wire is 1.5A/sqmm.

ii) **Insulators**

Insulators are materials that do not conduct electricity in form. They are used to separate two wires to avoid partial contact of any form.

3. CONSTRUCTION

In the construction, the laminated core was arranged first to form the three poles as shown below,

The total laminated core used for the **I** shaped, of size (70*220) mm is 600 strips, another I shape of size (70*170) is 400 strips, and one more I shape of size (70*270) is 200 strips. Total of 1200 laminated core used in all. In the winding, the shape of the laminated core was taken and a core was form for the winding of the coil. The next step was the fixing of the coil in the pole and pole and the crossing of the top of the machine with an 'I' laminated core to avoid Butt joint. The construction work is as shown.

A) Connections

The major kinds of connections that can be given to this construction include.
a) star-delta connection or end to start connection
b) star-star connection or star to start connection
c) Delta-Delta connection or end to end connection

B) Tests of Welding Transformer

A transformer may be subjected to a range of tests for a variety of purposes,
Including.

i) Routine tests after manufacture
ii) Acceptance tests. Heat runs, etc.
iii) Specialized investigations on particular details of design, performance or operation.

There are following Routine Tests of Welding transformer

i) Insulation Resistance Test
ii) Open Circuit Voltage Test
iii) Load Characteristic Test
iv) Short Circuit Test
v) High Voltage Test

i) Insulation Resistance Test –

The insulation resistance before and after high voltage test shall be not less than two mega ohms. The insulation resistance shall be measured with D.C. voltage of about 500 volts applied for a sufficient time for the reading of the indicator to become practically study, such voltage being taken from an independent source or generated in the measuring instrument. This is required to ensure low leakage current to flow through the earth and safety purposes.

ii) Open Circuit Voltage Test –

With input side connected to the rated input voltage and output side open circuited, the open circuit voltage (of secondary output) shall be measured. In normal case it should not exceed, 80 volts (R.M.S.) in special cases, it is permissible for the open circuit voltage to be up to 100 volts (R.M.S.) The permissible tolerance for the O.C. voltage is 5%.

iii) Load Characteristic Test –

The transformer shall be connected to the rated input voltage. The output terminals shall be connected to the variable resistive load. The relation between the welding load voltage and the welding current within the range of welding power source shall be in accordance with the formula U= 20+0.4 I, where 'U' is the load voltage and 'l' is the load current.
The accuracy of the current calibration should be +10/-20 percent up to the maximum continuous welding current, and +-10% for currents above
that. A table of welding current and welding load voltage can be as follows-

Table 5: showing the output load voltage and load current values.

Welding current (Amp)	Welding Load voltage (volts)
150	28-30
200	30-33
300	33-37
400	37-42
500	42-48
600	48-60

iv) Short Circuit Test –

Steady short circuit current at any setting with in the specified range shall be not more than 200 percent of the welding current corresponding to this setting. Under short circuit condition the voltage between output terminals shall not exceed 3 volts. while taking this test care shall be taken to ensure that the test shall not take more than 10 seconds.

v) High Voltage Test-

The transformer winding shall be capable of withstanding without breakdown the high voltage test. This test shall be applied once & to a new machine only. It shall be carried out at the manufacturers works and at the conclusion of the temperature rise test, if conducted.

4. RESULT AND DISCUSSION

Being a variable transformer selection type, the current at both input and output of the transformer were determined thus;

Table 6: showing the input and output voltage values from the welding machine.

Terminals	Prim. Turn N1	Sec. Turn N2	V in	V out	Scaling Factor Vout /Vin	Turn Factor Ns/Np
A	160	22	240	33	0.1375	0.1375
B	155	22	240	34	0.1466	0.1466
C	150	22	240	35	0.1458	0.1458
D	145	22	240	36	0.15	0.1501

The voltage in (Vin) was determined directly from the mains of power supply and recorded. The voltage out (Vout) was recorded when the transformer was connected to the power supply at zero load while the scaling factor is the ratio of the output voltage and input voltage. The turn factor was also calculated to determine the relationship of the turn given to the transformer and the scaling factor as shown above.

Table 7: showing the output load voltage and load current values.

	One holder (10-gauge rod)	Two holders (8-gauge rod)	Three holders (10gauge rod)
Voltage	34	58	34
Current	120 amp	180 amp	120 amp

In three phase welding machine we use three holders at a time for low work. we can use two holders at a time for medium work and for heavy work. Also, we can use single user or two users for low, medium and heavy work.

5. CONCLUSIONS

There are different types of welding machines available in market, like 1phase, 2phase welding machines depending upon current rating e.g., 150- amp, 200-amp, 300-amp, 400-amp, 500-amp, 600 amp. But all machines are available in 1phase 230volt and 2phase 440volt and all machines have only single user.

In domestic and industry sector, welding machines perform and completes very important role, there are different types of welding machines used e.g., MIG-Gas Metal Arc Welding (GMAW), TIG-Gas Tungsten Arc Welding (GTAW), Stick Shielded Metal Arc Welding (SMAW) and Flux cored Arc Welding (FCAW). All the welding machines are 1phase and 2phase in nature and only one user can workon one machine, no other one user can work on same machine. If we use another holder for welding then we should use another welding machine, so it will increase cost of machine, it takes some space, energy use, so, by using three phase welding machine we can overcome this problem. In three phase welding machine we use three holders at a time for low and medium work and for heavy work we can use two holders at a time. Also, we can use single user or two users for low, medium and heavy work.

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