PHASE SHIFT VOLTAGE CANCELLATION SYSTEM

4 Claims, 1 Drawing Fig.

ABSTRACT: A system for energizing the components of a wire strap heat treating process to prevent unsafe voltage conditions from occurring on the strap wherein heating power and majority voltage cancellation are supplied from a common distributed transformer arrangement and trimming cancellation of voltage is effected in an auxiliary transformer, the latter comprising a phase shift autotransformer arrangement energized from all phases of the three phase power source.
PHASE SHIFT VOLTAGE CANCELLATION SYSTEM

This invention relates to heat treating systems and more particularly to a voltage cancellation system utilized in conjunction with a direct resistance heat treating system for wire or strapping and the like wherein a cancelling voltage is magnetically induced in the material to be heated in opposition to the directly applied voltage to prevent the occurrence of a potential in the material dangerous to operating personnel and the like.

Several different techniques have been utilized in the past for preventing this dangerous voltage condition from occurring including the establishment of plural heating zones utilizing multiple taps on a power transformer as well as the magnetically induced voltage cancellation technique. The first-mentioned type of system is somewhat unwieldy in requiring additional components in the system and additional contact with the material to be treated. Such system requires multiple heating zones and attendant isolation together with a complicated construction of a multiple tap transformer all of which combines to detract from the operating efficiency of the overall system.

Much greater success is realized in the magnetic voltage cancellation technique wherein an induced voltage is generated in the material to be treated obviating the contacting pitting problems and local heating effects inherent with the direct contact cancellation devices. In the past such systems, however, have not been completely successful in reducing or cancelling the directly applied voltage to a zero level in that due to the inductive and capacitive characteristics of the system, phase shifts in voltage occur under different operating conditions and the voltage is difficult to compensate.

Therefore, it is one object of this invention to provide an improved voltage cancellation system for the direct resistance method of heating wire strapping and the like which magnetically introduces a phase-shifted compensating voltage sufficiently to avoid local heating or voltage problems.

It is another object of this invention to provide an improved voltage cancellation system which utilizes all phases of a three phase power source to achieve the required phase shift and attain the necessary amplitude of compensating voltage.

It is yet another object to provide an improved magnetic voltage compensating system for direct resistance heating system by drawing preferably automatically a minimum of contact devices for achieving the required compensating voltage under any operating condition, such voltage to be manually trimmed to optimize the minimum level.

The single drawing in this description of the invention is a schematic diagram of the complete process line showing the relative disposition of the heating zone and the voltage compensating zone together with typical components utilized.

In the drawing there is shown a three-phase source of power 10 for complete energization of the direct resistance heating system, such source of power being connected to three transmission lines 11—13 for distributing the energy to various portions of the system. In this embodiment of the invention the power source 10 will be considered a typical 480 volt to neutral three-phase power source commonly utilized in plant or factory environments although it will be understood that the teachings of this invention are applicable with any multiphase power source providing various voltage levels for application to a heating system. It will be understood that the various phases of the power source are related as differing in phase by 120° as is well understood in the art.

In the drawing, the direct resistance heating system is shown in schematic comprising a supply or drum 15 for storing the wire or strapping material 16 to be treated in the system. The material to be heated is depicted as a single line 16 emanating from the supply drum 15 and directed to various other portions of the system, and such line may be indicative of a plurality of wires or lengths of strapping which are directed in parallel throughout the system and which are contained on the supply drum 15 in parallel wraps. The material 16 is passed through the voltage cancellation portion of the system indicated at 18 and generally defined as between first and second guide rollers 19, 20 engaging and supporting the material 16. The guide rollers 19, 20 may be metallic drums in electrical contact with the material 16 or may be insulative supports, but in any event, are electrically floating so as to avoid transferral of energy to or from the material 16 and to obviate contact pitting problems.

The material 16 is then transported through the voltage heating portion 21 of the system defined generally by a contact bath 23 and a quench bath 22 which serve to apply heating power directly to the material 16. The material 16 is eventually wound upon a takeup drum 24 for storage purposes and later utilization, it being understood that both the supply 15 and take up drums 24 are continuously rotated and the material 16 is transported through the system in a continuous heat treating process.

The contact bath 23 is well known in the art and comprises a container 25 through which the material 16 is directed by further guide rollers 26 and contains an electrically conductive liquid medium such as liquid lead for contacting the material 16 over sufficient area to avoid localized pitting of the material 16. The quench bath contact 22 is also well known in the art comprising a conductive container 28 filled with a quenching medium 29 such as liquid lead which provides good contact with the material 16 under treatment for both electrical and heat removal purposes and which supplies a coating to prevent oxidation thereof. The quench bath 22 comprises further rollers 30 therein for supporting and changing the direction of the material 16, such rollers 30 being immersed in the lead 29 of the bath, but not otherwise significant to the teachings of this invention.

As noted in the drawing the container 28 for the quench bath 22 is connected by means of an electrical line 32 to ground potential. The quench bath 22 further comprises an energizing line 33 connected to the container 28 while the contact bath 23 also has an energizing line 35 connected to the container 25 and therefore to the material 16 to be treated.

In this direct resistance heating system energizing potential is applied between the contact bath 23 and the quench bath 22 to effect heating of the material 16 therebetween and since both the container 28 of the quench bath 22 is at ground potential, the contact bath 23 will be elevated in potential with respect thereto. In such typical operation and in the absence of voltage cancellation in zone 18, the potential of the contact bath 23 will appear in the material 16 throughout its length previous to the contact bath 23 rendering the supply drum 15 also at such potential, thereby presenting a dangerous condition to any personnel in the area of the apparatus.

As noted, it has been known in the past to apply opposing voltages directly to the material 16 by means of a three contact system (not shown) wherein a center tapped power transformer is utilized with the outer leads being connected, for example, to the first guide roller 19 and quench bath 22 respectively, with such components being maintained at ground potential and with the center tap lead being connected to the contact bath 23 of the system. Such arrangement creates two heating zones between the roller 19 and contact bath 23 and between the contact bath 23 and quench bath 22 and although achieving a safety of operation introduces additional local heating effects where the contact roller 19 engages the material 16 together with introducing the additional problems of isolating the two heating zones of the system from operating personnel.

A much better solution to the problem of minimizing extraneous voltages is the magnetic induction concept in which voltages or currents in opposition to the voltage applied between the contact bath 23 and the quench bath 22 are introduced in the material 16 between the guide roller 19 and contact bath 23. Such mode of operation avoids contact pitting problems and as in this embodiment of the invention,
such magnetically induced voltage may be supplied from the same transformer arrangement which supplies the heating voltage for the system.

Energizing power for the system is received from lines 12, 13 as one phase of the three-phase power source 10 by means of input leads 38, 39 via an air circuit breaker 40 and an induction regulator 41. The induction regulator 41 is not significant to the teachings of this invention but is merely shown in the preferred embodiment to indicate the regulator effective desirable upon the voltage eventually applied to the contact bath 23 and quench bath 22 of the system. The output of the induction regulator on lines 38, 39 is normally a 480 volt, 60 cycle source of voltage.

The transformer for inducing voltage into the material 16 and for supplying the voltage to the electrical contacts for the direct resistance heating is a combination type transformer indicated generally at 42 and comprising eight individual transformers 44, indicated 44a—44h, interconnected to provide suitable voltages and magnetic characteristics. The transformers 44 are situated in the process line between the supply drum 15 and contact bath 23 and are spaced apart to some extent to provide a compensating action upon different portions of the material 16 during its traverse through the system.

Each of the transformers 44 consists of a magnetically permeable core of generally rectangular or circular configuration, and having a central aperture therein as at 45 through which the material 16 to be treated is transported. Both primaries 46a—46h and secondary 48a—48h windings are wound on the transformers 44 in the manner well understood in the art, being magnetically coupled via the close placement of the respective windings and the permeable characteristics of the magnetic core. Such windings are not shown in detail in the drawing but are indicated merely by the primary and secondary input connections respectively indicated by a pair of terminals.

The primary windings 46 of the transformers 44 are connected in parallel to the power lines 38, 39 from the induction regulator 41, and similarly the secondary windings 48 are connected in parallel to provide output voltage to the contact bath 23 and quench bath 22 by way of lines 35, 34 respectively.

By such connection the relatively high 480 volt supply voltage applied to the primary windings 46 of the transformers 44 will be stepped down to a suitable secondary voltage of about 145 volts, which is further reduced to the material 16 while allowing a very high current flow to occur. The primary 46 and secondary 48 windings may be interconnected in various other arrangements to achieve different operating current levels and/or voltage cancellation effects and for a further description of such arrangements, as well as of the transformer and other component construction, reference is made to Pat. No. 3,427,430, issued Feb. 11, 1969.

The magnetic fields of the primary windings 46 act on the material 16 traversing the central apertures 45 of the transformers 44 to induce therein voltages to substantially cancel that applied directly by way of the contact bath 23 and the quench bath 22. By such cancellation of voltage it may be seen that even though the guide roller 19 is not connected to ground potential, the voltage appearing in the material 16 at the guide roller 19 is substantially at ground potential and is not hazardous to operating personnel. Thus, the supply drum 15 is also at ground potential and may be conveniently supported and rotated by any suitable form of apparatus, without the necessity for isolating the apparatus electrically, which minimizes the cost of manufacturing such a system and enhances the safety of same.

It will be obvious, however, due to the individual transformers 44 and the discrete voltage obtainable from each, that it will be difficult to entirely compensate the voltage appearing in the material 16 prior to the contact bath 23. This problem is further accentuated by the inductive characteristics of the transformers 44, the capacitive characteristics of lead wires and the like as well as the load impedance of the material 16 being treated. In effect, the voltage induced in the material 16, which acts as an additional secondary winding of the transformer 42, will not exactly equal in amplitude or in phase, the voltage realized at the secondaries windings 48 to effect a complete compensation. For this reason a trimming transformer 50 is inserted between the guide roller 19 and the voltage compensation transformer 42 to provide a means for reducing the actual voltage appearing in the material 16 at the guide roller 19 to an effective zero condition, any small residual voltage remaining being insignificant for the purposes of heat treating or wire stranding and the like.

The trimming transformer 50 is a transformer similar to those previously described having a primary winding 51 but not requiring a secondary winding on the core. The transformer 50 includes a similar central aperture 52 and the material 16 to be treated is directed through this aperture. Energization of the trimming transformer 50 is accomplished by the application of a voltage, variable both in amplitude and in phase, derived from the interconnection of a dual autotransformer arrangement.

A first auto-transformer 55 which comprises a transformer coil 56 and slidable tap 58 for engagement therewith is connected to two lines 11, 12 of the three-phase power source 10 through a pair of contacts 59a, b forming a part of an energization relay (not shown). A second auto-transformer 60 has its coil 61 connected at one end to a third line 13 of the AC source 10 via a third contact 59c of the same relay and the other end is connected to one lead of the primary winding 51 of the trimming transformer 50 and also to the slidable tap 58 of the first auto-transformer 55.

The slidable tap 62 of the second auto-transformer 60 is connected as the second input to the primary winding 51 of the trimming transformer 50 by way of line 64.

Noting the connection of the first auto-transformer 55 to the transmission lines 11, 12 and the connection of the primary windings 46 of the transformer 42 to different transmission lines 12, 13, it will be appreciated that a voltage of different phase will be realized at the slidable tap 58 of the auto-transformer 55 for application to the trimming transformer 50. The further connection of the second auto-transformer 60 to the third 13 of the transmission lines can affect a further phase shift; however, in actual practice it has been determined that the first auto-transformer 55 provides the essential phase shift for the system while the second auto-transformer 60 acts primarily to alter the amplitude of the signal applied to the trimming transformer 50. It will be noted, however, that both auto-transformers 55, 60 are interconnected in operating so that both affect the phase and amplitude of the output signal to some extent.

The auto-transformers 55, 60 and trimming transformers 50 may be energized by the closure of the contacts 59a—c from an external control if the trimming voltage is desired and it can be appreciated that the action of the trimming transformer 50 is sufficient to reduce the voltage in the material 16 at the guide roller 19 to a much smaller level than obtainable with the discrete cancellation of a multiple transformer arrangement and will avoid the contact pitting problems and the undesired current flow in the material prior to the contact bath 23.

I, therefore, particularly point out and distinctly claim as my invention:

1. Apparatus for direct resistance heat treating and cancellation of voltage in a continuously moving length of material, comprising take up and supply means for supporting and continuously transporting the material, first and second means in electrical contact with the material for applying heating energy thereto, said first and second contact means being spaced apart to define a heating zone and being located between said take up means and said supply means, a first transformer for supplying heating and cancellation voltage to the material, said first transformer having a primary winding energized from one phase of a plurality phase source and a secondary winding operatively connected to said first and second contact means, said first transformer further having an apertured core
and being located between said first contact means and said supply means for voltage cancellation purposes, the material being directed through the core of said first transformer, a trimmer transformer located adjacent said first transformer for additional voltage cancellation in the material, said trimmer transformer having an apertured core through which the material is also directed and a primary winding adapted for energization, and first and second adjustable transformers operatively interconnected for adjustable energization of said primary winding of said trimmer transformer, said adjustable transformers being energized from a different phase of said plural phase power source than said one phase energizing said first transformer to provide both phase and amplitude voltage cancellation.

2. Apparatus as set forth in claim 1 wherein said first and second adjustable transformers comprise autotransformers, each having a coil and slidable tap thereon, the coil of said second autotransformer being connected to the slidable tap of said first autotransformer for interdependent control.

3. Apparatus as set forth in claim 2 wherein the power source is a three-phase power source having first, second and third transmission lines, the coil of said first autotransformer being connected to said first and second transmission lines, and the coil of said second autotransformer being connected to said third transmission line.

4. Apparatus as set forth in claim 3 wherein said first transformer comprises a plurality of transformers of similar construction aligned and distributed in the direction of movement of the material for voltage cancellation over an appreciable length of the material, the secondary windings of said plurality of transformers being connected in parallel and to said first and second contact means, and said trimmer transformer being located between said plurality of transformers and said supply means.