ABSTRACT OF THE DISCLOSURE

A system for controlling an electric emulsion treater or the like which has a varying current load. The apparatus provides for measuring the load current, opening the circuit to the load when a predetermined current value is exceeded, maintaining the circuit open for a period of time, and then closing the circuit to the load.

This invention relates to new and improved systems and methods for controlling the operation of electric emulsion treaters and other apparatus having randomly varying current loads. It finds particular utility in conjunction with electric dehydrators designed to separate suspended aqueous material from crude oil emulsions or in conjunction with other electric treaters that must be able to treat emulsions that vary from time to time in electric conductivity or electric treatability.

A typical apparatus for which the control system of the invention is intended to be used is an electric emulsion treater adapted to treat oil-continuous emulsions to separate the dispersed phase thereof, composed of drops of a material of higher electrical conductivity, often aqueous in nature. Such a treater utilizes two or more spaced electrodes immersed in the fluid being treated, with a high electrical potential between the electrodes to maintain a high voltage electric field therebetween.

The conductivity of the oil being treated is normally influenced by the droplets of water dispersed in the oil, with the quantity, size and relative positions of the droplets varying randomly during the operation of the treater and thereby producing a randomly varying current load. Occasionally groupings of the water droplets are aligned up by the action of the electric field and form a very low resistance path between the electrodes resulting in a very high current load until this chain of droplets is disrupted. Variations in the load current and the overall electrical system from damage due to these high current loads. Also, various control systems have been utilized to vary the operation of the treater during the high current conditions in attempts to improve the treating action.

It is an object of the present invention to provide a new and improved system for controlling the operation of an electric treater to provide better control under high load conditions and a system which is simple, automatic and relatively inexpensive. An additional object is to provide such a control system which is not limited to use with electric emulsion treaters and which may be utilized with a variety of apparatus having randomly varying load currents and requiring protection against high current loads.

Various systems are being used today for control with randomly varying loads. Air gap rectifiers and saturable core reactors are employed as current limiting devices with the reactor connected in circuit between the power source and the load. These devices often function satisfactorily to limit high current loads but introduce reactive impedance into the system and require much higher kva. ratings for the power source and the equipment. Fuses and circuit breakers are also employed for overload current protection but require replacement or resetting after circuit interruption and hence do not provide for automatic or continuous operation of the treater or other apparatus. Accordingly it is an object of the present invention to provide a system for controlling electric treaters and the like which system does not introduce additional reactance into the load, thereby permitting utilization of transformers rated at the normal load demand and permitting operation with lower kva. requirements from the power source. A further object is to provide such a system wherein the only reactive impedance is that of the high voltage stepup transformer which has an inductive reactance in the order of five to thirty percent and preferably within the range of about ten to twenty percent. An additional object is to provide such a control system which provides continuous operation with automatic protection against high current loads without requiring supervision and at the same time being less expensive initially and more economical to operate.

It is an object of the invention to provide a system for controlling electric power supplied from a pair of line terminals to an electric emulsion treater or the like which produces a varying current load at a pair of load terminals, the system including switch means connected between the line terminals and the load terminals for opening and closing a circuit between the line load terminals, current sensing means for developing a current signal varying as a function of the current load in the circuit, control means coupled to the switch means for actuating the switch means to circuit open and circuit closed conditions, means connecting the current signal to the control means as an input with the control means adapted to actuate the switch means to the open condition when the load current exceeds a predetermined value and to actuate the switch means to the closed condition when the load current is shut off, and delay means for delaying the closing of the switch means for a predetermined period of time after the load current is shut off. A further object is to provide such a system which may utilize for the switch means various conventional switching devices such as controlled rectifiers in the form of silicon controlled rectifiers, gas rectifiers with grid control, and the like, and mechanically moving contact sets.

It is a further object of the invention to provide such a control system including means for terminating the automatic circuit closing operation after the control system has opened and closed the power circuit for a predetermined number of times. This type of shut-off provides for protection against short circuits and other long-term over-current producing conditions. Means may be provided for manually resetting the system after such a shut-down or for automatically resetting the system after a longer predetermined period of time has elapsed.

It is a particular object of the invention to provide such a control system wherein utilization of the load connected to the power source, as represented by the combined control system and treater, is increased by a factor of about two over systems utilizing reactor control.

The invention also comprises novel details of construction and novel combinations and arrangements of parts, which will more fully appear in the course of the following description. The drawing merely shows and the description merely describes preferred embodiments of the present invention which are given by way of illustration or example.

In the drawing:

FIG. 1 is a diagrammatic illustration of a preferred embodiment of the invention used with an electric emulsion treater;
FIG. 2 is an electrical diagram of one form of the control and switch of FIG. 1; FIG. 3 is a schematic showing the totalizer of FIG. 2 in greater detail; FIG. 4 is a diagram illustrating another form of the control switch of FIG. 1; and FIG. 5 is a diagram illustrating an alternative embodiment of the invention.

Referring to FIG. 1, an electric treater 10 is energized from an A.C. power source via a high voltage stepup transformer 11 which typically may have a primary rated at 440 volts and a secondary rated at 16,500 volts. The construction of the treater itself is not varied as a function of location and a conventional emulsion breaking electric treater is illustrated as typical of an apparatus having a relatively high and randomly varying current load. The illustrated treater 10 incorporates an upright cylindrical container 12 closed at both ends. A set of ferromagnetic electrodes is disposed in a horizontal pattern within the container, including an electrode 13 connected to one side of the secondary winding of the transformer 11 via a conductor 14, a feedthrough or inlet bushing 15 and another conductor 16. Another ferromagnetic electrode 17 is disposed above the electrode 13 and may be grounded. In operation the control system automatically energizes the electrodes 13 and 17. A high pressure fluid such as the inedible oil and separated water and the water at and below the interfacial zone 18 may act as another grounded electrode. The container 12 and the other terminal of the transformer secondary winding are connected to ground, and the container itself may act as a grounded electrode.

The oil to be treated is pressurized by a pump 20. In some instances a supplementary liquid is desirably mixed therewith and conditioning chemicals may also be added to the material to be treated. A small amount of water or other liquid may be introduced from a line 21 in an amount not to exceed a pump 22. A conditioning chemical may be introduced from a line 23 in an amount controlled by a pump 24. A mixing device 25 may be provided in the line to mix the various streams and the mixed emulsion is discharged into the container 12 through a nozzle 26 directed upward against a baffle 27. The treated oil leaves the container through a line 28 and water or other material coalesced by the electric field and separated from the oil leaves through a line 29. Reference may be had to U.S. Patents Nos. 2,182,145 and 2,880,158 for a more detailed description of the construction and operation of an electric emulsion treater.

The control system of the invention is connected in circuit between the A.C. line terminals 33, 34 and the load terminals, which may be considered the conductor 16 and ground. The control system normally is connected in the primary or low voltage side of the transformer 11 but could be utilized in the high voltage side if desired. A conventional circuit breaker 35 ordinarily is connected in the circuit at the line terminals to provide overall protection for the entire system. A switch 36 is connected in circuit between the line and load terminals, typically between the circuit breaker 35 and the transformer 11. This switch provides for opening and closing the circuit between the line and load terminals. A control 37 is connected to the switch 36 for actuating the switch to the circuit open and circuit closed conditions. A current sensor 38 is provided in the line for sensing the magnitude of the current load and this typically may be a current transformer, or a thermal or a magnetic sensor. The current signal which varies as a function of the load current and this signal is connected as an input to the control 37.

When the current load exceeds a predetermined value, as would occur when chaining of water particles between electrode elements in the treater occurs, the control 37 acts to operate the switch 36 and open the circuit between the line and load terminals, thereby completing the shutting off electrical power to the treater. This of course results in an immediate drop in the load current and the current signal indicates that the switch 36 may be closed. However, the control 37 includes a time delay which prevents reclosing of the switch for a predetermined period of time. At the expiration of the time, the control acts to close the switch and restore electrical potential to the treater or other load.

One specific set of elements suitable for the switch 36, control 37 and current sensor 38 is illustrated in FIG. 2. The circuit between the line and load terminals may be mechanically opened and closed by two sets of contacts 40, 41 driven by a solenoid 42. Devices of this type are readily available and sometimes are referred to as contacts. The circuit to the solenoid 42 is through a contact set 44 and, when used, another contact set 45. The contact set 44 may be part of an overcurrent relay 46 of the thermal type connected in the line between the breaker 35 and the switch 36. The overcurrent relay 46 may be a conventional device and preferably incorporates an adjustment either mechanical or electrical for setting the current level at which the relay will be actuated to open the contact set 44 to de-energize the solenoid 42 and thereby open the contact sets 40, 41. When the current falls below a value, usually less than the value at which the overcurrent relay is initially actuated because of the inherently high resistance of the device, the contact set 44 is closed and the solenoid 42 is energized. The contact sets 40, 41 are not immediately closed because of a time delay due to thermal lag. In addition, a conventional pneumatic time delay may be incorporated in the mechanism linking the solenoid to the contact sets 40, 41. Alternatively, such a time delay may be incorporated in the overcurrent relay 46 or an electrical time delay may be utilized at the input to the overcurrent relay or at the input to the solenoid 42.

The contact set 45 is part of a totalizer 50 which is a desirable but not essential feature of the control system of the invention. When the totalizer is not utilized, the contact set 45 may be omitted, with one end of the solenoid 42 directly connected to the power source. The totalizer 50 functions to count the number of interruptions produced by the switch 36 and when the count reaches a predetermined number, the totalizer will disable the control system preventing further application of potential to the load. A typical arrangement for this function is illustrated in FIG. 2 and may include a stepping or counting relay 51 for driving the contact set 45. Voltage pulses produced in the line 52 from the power source to the solenoid when the solenoid is energized are sensed and are used to advance the counting relay one count per pulse. The counting relay may be manually set to shut down the system after any desired number of interruptions. The counting relay may also be utilized to sound an alarm or give any other indication of system shutdown. The counting relay may be reset manually or an automatic reset may be utilized providing resetting to the initial count state after some desired period of time has passed.

A specific example of a totalizer is illustrated in FIG. 3, incorporating a stepping relay 51 with a coil 54, a six-position contact deck 55, and a moving contact 56. A manual reset switch 57 is provided for stepping the relay from the open contact 58 to the next contact. With this particular relay, the system will be shut down after five switching cycles until manually reset. The totalizer may be used in combination with any of the forms of the invention described herein.

Controlled rectifiers may be used for the switch 36 and a system utilizing solid state silicon controlled rectifiers 60, 61 is illustrated in FIG. 4. The rectifiers 60, 61 are turned on and off by the contact set 44 with a conventional control circuit incorporating resistors 62, 63, 64 and diodes 65, 66. Similar systems can be utilized with gas rectifiers such as thyatrons and ignitrons.

FIG. 5 illustrates an alternative embodiment incorporating two completely separate circuits having different operating characteristics providing an overall current characteristic which is a composite of the individual
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sensors and control units. It was stated earlier that various sensors, including thermal and magnetic devices, could be used, and a thermal overcurrent relay 46 was illustrated in FIG. 2. In the embodiment of FIG. 5, the sensor portion of a magnetic overcurrent relay 70 is connected in series with the sensor portion of the relay 46 providing the composite operation. The contact set of the relay 70 may be connected to the switch 36 for operation in the manner as with the relay 46.

The control system of the invention provides automatic current overload protection and automatic restoration of power for a device such as an emulsion treater which is characterized by randomly varying current loads. This automatic operation is achieved without introduction of reactive impedance into the system so that the principal reactance in the overall load connected to the power source is that of the high voltage transformer. The reactance of the transformer provides some regulation in the system and limits peak values of high transient currents. Desirably the reactance is in the range of five to thirty per cent and preferably in the range of about ten to about twenty percent. The higher portion of the range is preferred for using a mechanical switch and the lower portion of the range is preferred when using an electronic switch.

The system of the invention permits reducing the kva. requirements of the source and components to substantially the kva. requirements of the treater. For example, in a present-day system using an air gap reactor for overcurrent protection with a 440 volt primary on the transformer providing 2 kw. to the treater, the line voltage at the terminals 33, 34 must be 480 volts and the source rating may be 10 kva. Substitution of the control system of the invention for the air gap reactor permits reduction of the source rating to 3 kva.

In the operation of the control system of the invention, the time delay between opening and closing of the circuit from the line terminals to the load terminals may be in the order of twenty to sixty seconds. In an alternative method of operation, the time delay between circuit opening and circuit closing may be made relatively short, such as in the order of ten to sixty cycles of the A.C. power source. The system may be adjusted so that normal continuous A.C. treatment is obtained with normal electrical loads and interrupted A.C. operation is achieved with higher electrical loads such as result from occasional chaining of water particles. This mode of operation can be obtained by setting the control 37 to open the circuit at, say 110% of rated current load. The interrupted A.C. operation is beneficial in breaking the chains and is beneficial in restoring the treater to a more stable operation following operational disturbances often encountered in the operation of electric treaters of this type.

Although exemplary embodiments have been illustrated and described, it will be apparent that the invention is applicable to various electric emulsion treaters and other varying current loads. In the field of electric emulsion treatment the invention is excellently suited to the dehydration or desalting of crude oil and to the removal of dispersed conductive material from other oils. The term emulsion as herein used is definitive of dispersions ranging from mere temporary dispersions that will settle on standing to the emulsions stabilized to such extent as not to settle substantially on prolonged standing.

We claim as our invention:

1. In a system for controlling the electric power supplied from a pair of line terminals to an electric emulsion treater or the like which produces a varying current load at a pair of load terminals, the combination of:

   a first current sensing means having constant reactance and developing a first switching signal a period of time after the current load in the circuit exceeds a predetermined value;

   a first control means coupled to said switch means for actuating said switch means to the circuit open and circuit closed conditions;

   a first means connecting said first switching signal to said first control means as an input, with said control means adapted to actuate said switch means to the open condition on receiving a switching signal and to actuate said switch means to the closed condition when the load current is shut off;

   delay means for delaying the closing of said switch means for a predetermined period of time after the load current is shut off;

   a second current sensing means connected in the same line as the first sensing means and developing a second switching signal varying as a function of the current load in the circuit;

   a second control means coupled to said switch means for actuating said switch means to the circuit open and circuit closed conditions; and

   second means connecting said second switching signal to said second control means as an input, with said second control means adapted to actuate said switch means to the open condition when the load current exceeds a second predetermined value and to actuate said switch means to the closed condition when the load current is shut off.

2. In a system for controlling the electric power supplied from a pair of line terminals to an electric emulsion treater or the like which produces a varying current load at a pair of load terminals, the combination of:

   switch means connected between the line terminals and the load terminals for opening and closing a circuit between the line and load terminals;

   current sensing means having constant reactance and developing a switching signal a period of time after the current load in the circuit exceeds a predetermined value;

   control means coupled to said switch means for actuating said switch means to the circuit open and circuit closed conditions;

   means connecting said switching signal to said control means as an input, with said control means adapted to actuate said switch means to the open condition on receiving a switching signal and to actuate said switch means to the closed condition when the load current is shut off; and

   delay means for delaying the closing of said switch means for a predetermined period of time after the load current is shut off.

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