Shield regulator protects against energy loss

Alberto Castoldi* describes a Variable Shield Regulator, its application in the glass furnace process and the energy savings it can obtain.

Voltage variation is required in a number of industrial and laboratory purposes and one of its main applications is in the boosting system of a glass furnace.

The introduction of a booster system in glass furnaces solves many problems in the furnace itself. These include improved movement of silica, improved temperature control of the process in the base and, consequently, an increase of production.

The boosting system has a large voltage and current range because the system must work in different conditions: With cold silica (high voltage, low current) and hot silica (low voltage and high current).

For this, the regulators have a larger dimensional power with respect to the rating power required.

The process is continuous and, for this reason, requires a maximum level of safety and a minimum level of maintenance during its campaign life. A Variable Shield Regulator (VSR) is the best solution to obtain the result described above.

How it operates

The regulator consists of a magnetic core with two windings connected in series wrapped in the opposite direction (winding A and B).

The supply voltage feeds the two opposing windings in series; the variable voltage output is taken from the junction of the two windings and the terminal of the winding B.

A secondary winding (C) closed in short circuit and without any electrical connection with the outside world, can move up and down.

The effectiveness impedance of winding B depends upon the position of the shielding winding C and will vary smoothly from small value when C is adjacent to B, to a large value when C is adjacent to A. The impedance of the winding A changes conversely in a similar manner. The impedance of winding A will be at its maximum value when the impedance of winding B is at its minimum value and vice versa.

The voltage across the individual winding A and B depends upon their relative impedance varies from nearly zero to a large proportion (even more than 100%) of the supply voltage.

From this system (basic principle), it is possible to achieve other circuits: Three-phases, three/two phases and booster systems. It is possible to obtain realisations that satisfy customer

demands, including any type of configuration, output voltages and output currents.

It is possible to achieve medium voltage regulator, low voltage regulator and high current regulators.

The study regarding the parameters of the VSR was made during years of collaboration with a University Research Department and Laboratory.

The study also allowed the control and optimisation of the operation with devices that make the machines electrically equivalent and higher than actual usage. The VSR system is patented by Stem Trafo.

Advantages

The advantages of VSR compared to standard regulators are due to its physical concept.

A possibility to make a regulation only moving a winding, without any contact inside, leads to the following advantages:

- There are no contacts subject to consumption. The moving of a shield winding is realised by a simple mechanism, which is reliable and with no maintenance necessary during the life of the regulator.
- The absence of skids or rollers allows the overload of the regulator. The rollers or skids have a low thermal time constant. If the current increases in respect to the rating value, the point of contact skid-winding immediately becomes hot. In the VSR the overload is similar to the standard transformer. With fans around the transformer it is possible to increase the power by approximately 20%. It is possible to work with a different duty cycle according to the time constant of the regulator itself.
- For the same reason the VSR can withstand the short circuit (in the old standard regulator the moving contact will be instantly damaged).
- During regulation there are no electric sparks as usually happens with standard and traditional regulators.

Flexible

The VSR is flexible regarding the volt and the ampere range. This makes it possible to manufacture regulators with low current (for example 40kA) or high voltage (theoretically, for example 130kV/0-130kV).

This is difficult with an old standard regulator because the realisation of moving contact is hard or impossible in

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the limit of the range (volt-ampere). For this reason with the VSR it is possible to study and realise boosting system solutions, referred to in the value of the old standard.

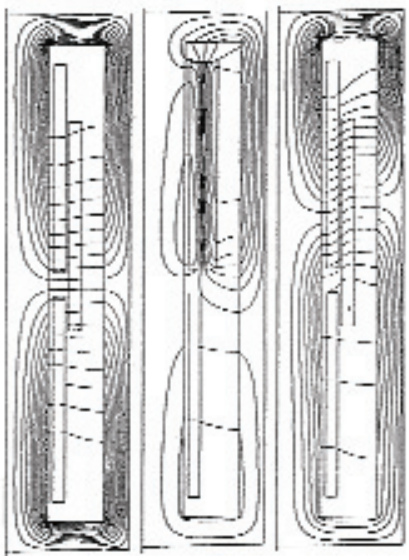
The VSR can work at full power between the nominal secondary volt and half of it. In this range, the nominal and dimensional power of the regulator is the same. In traditional regulators, it is necessary to double the dimensional power in respect to the nominal one to obtain the same result.

The VSR is similar to a reactor so there is no magnetic saturation in case of over-volt on the line.

Finally, because the realisation of the windings in the VSR is made with standard copper plate, and the core is the same as the standard transformer, the cost is cheaper compared to standard regulators.

Overdrive

In a booster system within a glass furnace, the output voltage varies from a value Vn to a value 0.2 Vn, but in reality the glass furnace has different needs. Usually, for 95% of its working life, it works with voltage values between 75% and 50% of the maximum voltage required and the maximum current can be ascribed mainly to this range.



▲ The leakage flux - diagram: (L) No load operation Middle and (R): On load operation.

An overdrive allows the system to optimise the efficiency.

As when a speed of a car is constantly on the highway and the overdrive gear enables a considerable saving of fuel, so the system overdrive allows significant savings on overall losses of the regulator.

In practice, it changes with off load tap changer (operating by hand without voltage), the voltage range from 0.2Vn to Vn, to 0.15Vn to 0.75Vn.

With overdrive there are two results: First, the current in the primary of regulator, at 0.75Vn, is the 75% of rated current, with a significant reduction of electrical losses in the winding, second, at 0.75%Vn, the regulator shall be a maximum and the shield regulator has maximum efficiency in this position.

The system allows overdrive in the performance of the regulator with savings of losses amounting to 15 - 20% (depending on secondary voltage), so increasing the efficiency of the system and consequently saving energy costs.

The dimensional power of VSR with overdrive is the same as nominal power, in most cases. The maximum current can be twice the size without changing the construction.

The constructive flexibility allows the energy requirements to be obtained in an optimal way. ■

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