The article describes the mechanism of coagulation of solid particles of internal combustion engines' exhaust gases as an aerodisperse system under the influence of an ultrasonic field. Some results of researches of scientists in this direction are presented. Groups of factors influencing coagulation rate, dependence of coagulation kinetics, characteristics of coagulation processes on parameters of ultrasonic influence are given. The device for cleaning of internal combustion engines' exhaust gases in transport equipment from solid particles and their utilization, which principle of work is based on intensification of processes of solid particles coagulation by ultrasonic influence is offered.

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OPTICAL VOLTAGE CONVERTERS BASED ON THE ELECTRO-OPTICAL EFFECT

The article contains the following materials.

Schematic representation of the concepts behind the optical sensing of varying electric and magnetic fields.

Optical current sensor based on the magnetic properties of optical materials.

Optical voltage sensor based on the electrical properties of optical materials. Conceptual design of a double-sensor optical CT. Alstom COSI-NXCT F3 flexible optical current transformer in a portable substation application. Optical voltage transducer concepts, using a «full-voltage» sensor. Installation of a CT with an optical sensor. Cross section of an Alstom CTO 72.5 kV to 765 kV current transformer with an optical sensor. Conceptual design of a Hall-effect current sensing element fitted in a field-shaping gap. Design principle of a hybrid magnetic current transformer fitted with an optical transmitter. Schematic representation of a Rogowski coil, used for current sensing.

Keywords: optical instrument transducer, non-conventional optical transducers, magneto-optic effect sensor, magnetic field, electric field, fibre optic cable.

INTRODUCTION

A permanent height of energy consumption and overload of power networks are reason of growing necessity of updating of senescent infrastructure of electroenergy industry. This fact presents a substantial problem, as from completion of tenure of employment of equipment the megascopic volume of maintenance is required. In addition, the traditional electro magnetic of transformers has a row of substantial defects following from nature of their work.

In modern energy, as well as in other industries of industry, there is swift motion toward development of digital technologies, therefore, all more often a question rises about the construction of digital substation and already made first advances in this direction.

Thus, in an electroenergy there is a requirement in digital measuring devices tensions that would provide, as compared to traditional transformers, higher parameters of safety and quality of measuring, therefore this project is actual and presents particular interest for development of industry on the whole.

The preceding types of instrument transformers have all been based on electromagnetic principles using a magnetic core [1, 2]. There are now available several new methods of transforming the measured quantity using optical and mass state methods [3, 4].

MAIN PART

Optical Instrument Transducers

Figure 1 shows the key features of a freestanding optical instrument transducer.

Non-conventional optical transducers lend themselves to smaller, lighter devices where the overall size and power rating of the unit does not have any significant bearing on the size and the complexity of the sensor. Small, lightweight insulator structures may be tailor-made to fit optical sensing devices as an integral part of the insulator. Additionally, the non-linear effects and electromagnetic interference problems in the secondary wiring of conventional VTs and CTs are minimized [5].

Optical transducers can be separated in two families: firstly the hybrid transducers, making use of conventional electrical circuit techniques to which are coupled various optical converter systems, and secondly the 'all-optical' transducers that are based on fundamental optical sensing principles.

Optical Sensor Concepts

Certain optical sensing media (glass, crystals, plastics) show a sensitivity to electric and magnetic fields and that some properties of a probing light beam can be altered when passing through them. A simple optical transducer description is shown in Figure 2.

If a beam of light passes through a pair of polarising filters, and if the input and output polarising filters have their axes rotated 45° from each other, only half the light comes through. The reference light input intensity is maintained constant over time. If these two polarising filters remain fixed and a third polarising filter is placed in between them, a random rotation of this middle polariser either clockwise or anticlockwise is monitored as a varying or modulated light output intensity at the light detector.

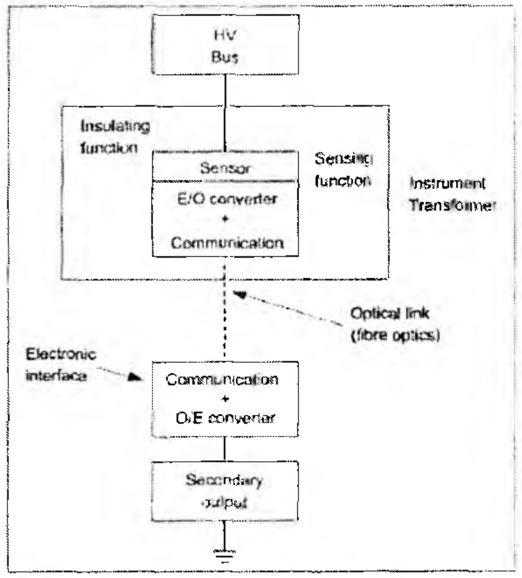

Figure 1 – Typical architecture using optical communication between sensing unit and electronic interface

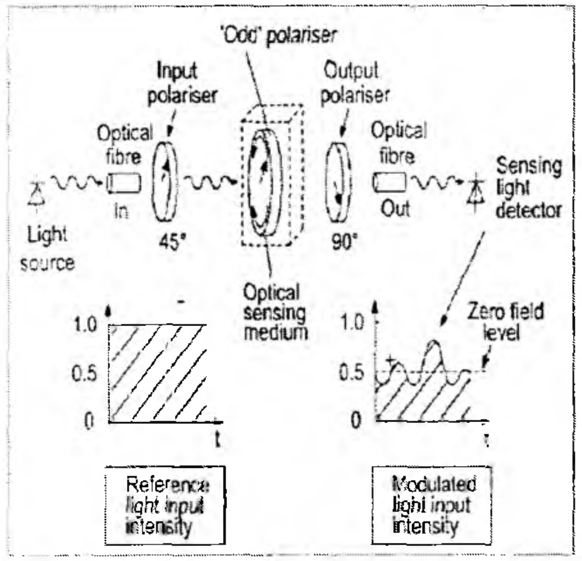

Figure 2 – Schematic representation of the concepts behind the optical sensing of varying electric and magnetic fields

When a block of optical sensing material (glass or crystal) is immersed in a varying magnetic or electric field, it plays the role of the «odd» polariser. Changes in the magnetic or electric field in which the optical sensor is immersed are monitored as a varying intensity of the probing light beam at the light detector. The light output intensity fluctuates around the zero-field level equal to 50 % of the reference light input. This modulation of the light intensity due to the presence of varying fields is converted back to time-varying currents or voltages.

A transducer uses a magneto-optic effect sensor for optical current measuring applications. This reflects the fact that the sensor is not basically sensitive to a current but to the magnetic field generated by this current. Solutions exist using both wrapped fibre optics and bulk glass sensors as the optical sensing medium. However, most optical voltage transducers rely on an electro-optic effect sensor. This reflects the fact that the sensor used is sensitive to the imposed electric field.

Hybrid Transducers

The hybrid family of non-conventional instrument transducers can be divided in two types: those with active sensors and those with passive sensors. The idea behind a transducer with an active sensor is to change the existing output of the conventional instrument transformer into an optically isolated output by adding an optical conversion system (Figure 2). This conversion system may require a power supply of its own: this is the active sensor type. The use of an optical isolating system serves to de-couple the instrument transformer output secondary voltages and currents from earthed or galvanic links. Therefore the only link that remains between the control-room and the switchyard is a fibre optic cable.

All-optical' Transducers

These instrument transformers are based entirely on optical materials and are fully passive. The sensing function is achieved directly by the sensing material and a simple fibre optic cable running between the base of the unit and the sensor location provides the communication link.

The sensing element consists of an optical material that is positioned in the electric or magnetic field to be sensed. The sensitive element of a current measuring device is either located freely in the magnetic field (Figure 3 (a)) or it can be immersed in a field-shaping magnetic «gap» (Figure 3 (b)). In the case of a voltage-sensing device (Figure 3) the same alternatives exist, this time for elements that are sensitive to electric fields. Both sensors can be combined in a single compact housing, providing both a CT and VT to save space in a substation.

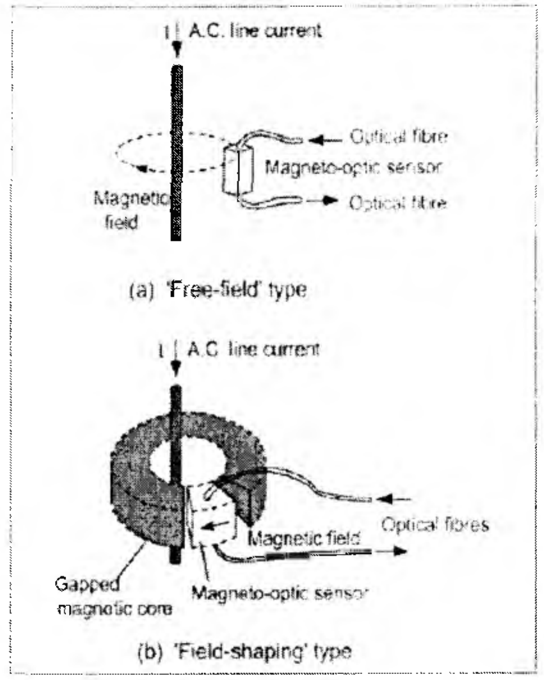

Figure 3 – Optical current sensor based on the magnetic properties of optical materials

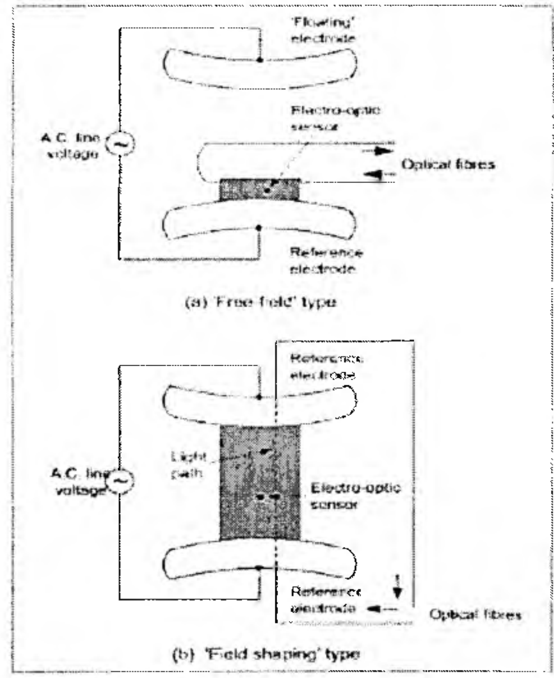

Figure 4 – Optical voltage sensor based on the electrical properties of optical materials

In all cases there is an optical fibre that channels the probing reference light from a source into the medium and another fibre that channels the light back to the analysing circuitry. In sharp contrast with a conventional free-standing instrument transformer, the optical instrument transformer needs an electronic interface module to function.

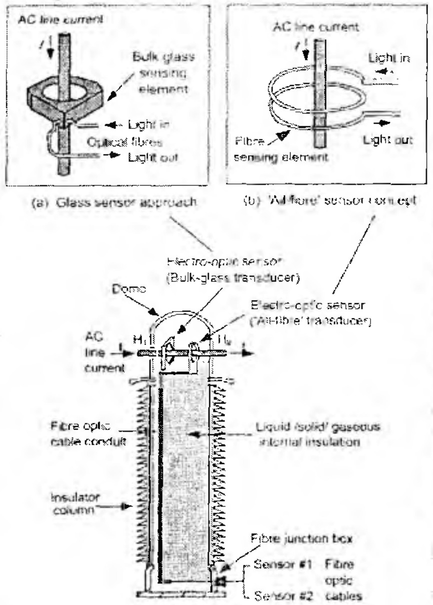

Figure 5 – Conceptual design of a double-sensor optical CT

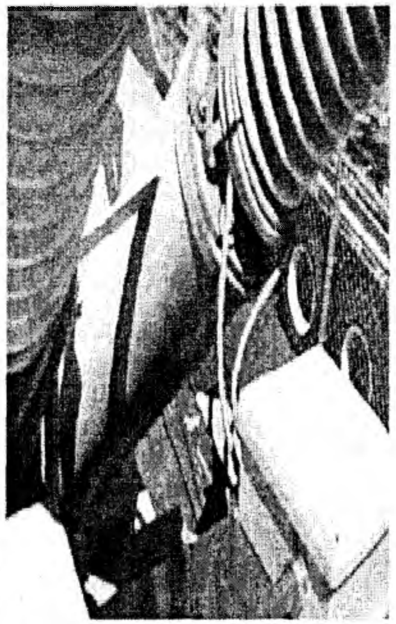

Figure 6 – Alstom COSI-NXCT F3 flexible optical current transformer in a portable substation application

Therefore its sensing principle (the optical material) is passive but its operational integrity relies on a powered interface.

Typically, current transducers take the shape of a closed loop of light-transparent material, fitted around a straight conductor carrying the line current (Figure 5).

In this case a bulk-glass sensor unit is depicted (Figure 5 (a)), along with a wrapped fibre sensor example, as shown in Figure 5 (b) and Figure 6. Light detectors are very sensitive devices and the sensing material can be selected to scale-up readily for larger currents. However, «all-optical» voltage transducers are not ideally suited to extremely high line voltages. Two concepts using a «full voltage» sensor are shown in Figure 7.

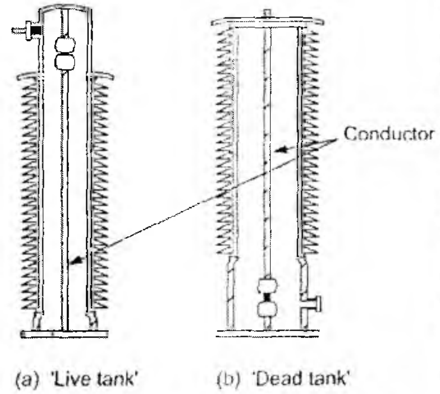

Figure 7 – Optical voltage transducer concepts, using a «full-voltage» sensor

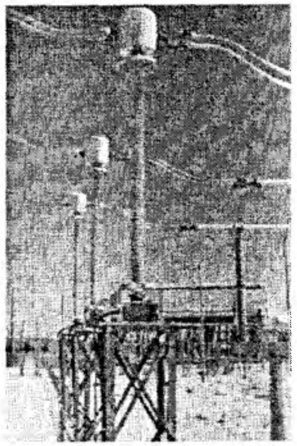

Figure 8 – Installation of a CT with an optical sensor

Other Sensing Systems

There are several other sensing systems that can be used, as described in the following sections.

Zero-flux (Hall Effect) Current Transformer

In this case the sensing element is a semi-conducting wafer that is placed in the gap of a magnetic concentrating ring. This type of transformer is also sensitive to d.c. currents. The transformer requires a power supply that is fed from the line or from a separate power supply. The sensing current is typically 0.1 % of the current to be measured. In its simplest shape, the Hall effect voltage is directly proportional to the magnetizing current to be measured. For more accurate and more sensitive applications, the sensing current is fed through a secondary, multiple-turn winding, placed around the magnetic ring to balance out the gap magnetic field. This zero-flux or null-flux version allows very accurate current measurements in both d.c. and high-frequency applications. A schematic representation of the sensing part is shown in Figure 10.

Hybrid Magnetic-Optical Sensor

This type of transformer is mostly used in applications such as series capacitive compensation of long transmission lines, where a non-grounded measurement of current is required. In this case, several current sensors are required on each phase to achieve capacitor surge protection and balance. The preferred solution is to use small toroidally wound magnetic core transformers connected to fibre optic isolating systems. These sensors are usually active sensors because the isolated systems require a power supply. This is shown in Figure 11.

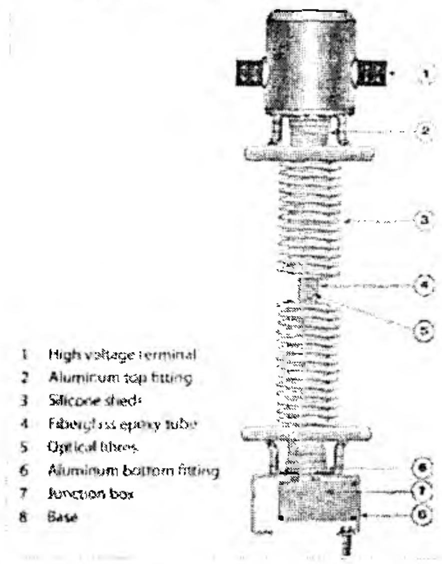

Figure 9 – Cross section of an Alstom CTO 72.5 kV to 765 kV current transformer with an optical sensor

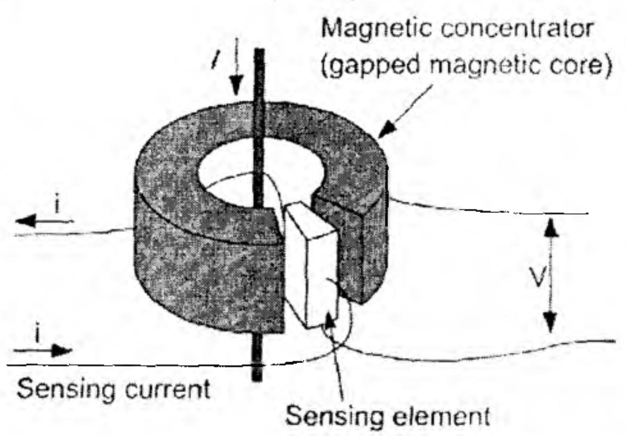

Figure 10 – Conceptual design of a Hall-effect current sensing element fitted in a field-shaping gap

Rogowski Coils

The Rogowski coil is based on the principle of an air-cored current transformer with a very high load impedance. The secondary winding is wound on a toroid of insulation material. In most cases the Rogowski coil is connected to an amplifier, to deliver sufficient power to the connected measuring or protection equipment and to match the input impedance of this equipment. The Rogowski coil requires integration of the magnetic field and therefore has a time and phase delay while the integration is completed. This can be corrected for in a digital protection relay. The schematic representation of the Rogowski coil sensor is shown in Figure 12.

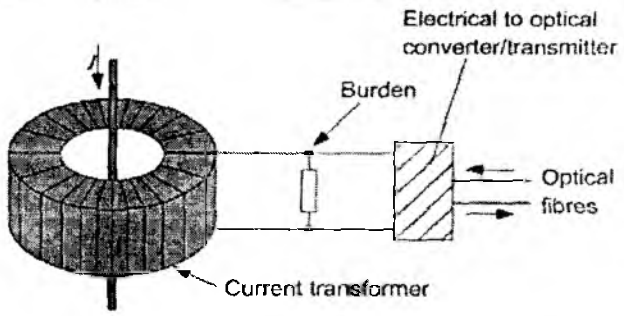

Figure 11 – Design principle of a hybrid magnetic current transformer fitted with an optical transmitter

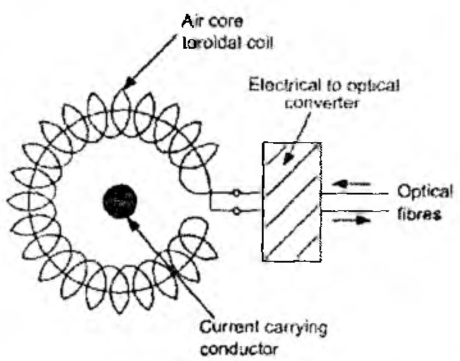

Figure 12 – Schematic representation of a Rogowski coil, used for current sensing

CONCLUSION

Schematic diagrams of electron-optical transformers are presented.

A typical architecture using optical communication between the sensing unit and the electronic interface is presented.

Examples of real applications of optical transformers are given.

The use of optical current and voltage measuring devices as part of commercial electricity metering systems will save tens of millions of tenge.

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