Stage II.1 Elaboration of documentation for the functional model

Stage objectives

Elaboration of documentation for the functional model, with the activities:

- Activity II.1 Elaboration of documentation for the functional model of the monitoring system for oil cooling circuit.
- Activity II.2 Elaboration of documentation for the functional model of the monitoring system for air cooling circuit.

Stage summary

Within this stage, the activities from the achievement plan have been achieved by CO-ICMET Craiova, P1-University of Craiova and P2-S.C.Simtech International Bucharest, having in view their compliance with the project objectives.

Activity II.1 Elaboration of documentation for the functional model of the monitoring system for oil cooling circuit.

For cooling the electric circuits (coils, etc.) and magnetic circuits (magnetic core), every power transformer is fitted out with batteries for forced cooling. So, in a cooling battery, by the forced circulation of insulating oil through the fan interstices (closed-type circuit with electric pump), the forced heat exchange with the environmental air (open-type circuit with electric fans) is carried out.

The heat flow released by the primary cooling medium – the transformer oil

$$\Phi_u = Q_u \cdot \rho_u \cdot c_{pu} (t_u' - t_u''),$$

in accordance with the mathematic model set in the previous stage of the project, implies real-time measurement of oil temperature and pressure parameters. Oil temperatures at the battery input and output are read by means of the temperature sensitive resistor type transducers. As regards the dynamic pressure (ρ_d) generated by the oil flowing at the battery output and necessary for calculating the flow rate Q_u, because of the phenomenon peculiarity, the reading can be made by a differential pressure transducer with Pitot tube.

This Pitot tube transducer has two circuits, where the differential pressure p_d and the static pressure p_s will be measured and read. At the battery input, a piezoelectric type pressure transducer will be also placed (p_s-static pressure), so as by comparing the static pressure at the input and output (pressure drop), diagnoses referring to the condition of the cooling batteries can be made.

The characteristic of transformer oil, like density ρ_u and specific heat c_{pu}, are taken from technical literature and presented in tabular form, depending on temperature.

The hardware structure of the monitoring system is represented in the plane MP1-9326, and the component characteristics are in accordance with technical specification. The interface between temperature transducers and system is provided by the conditioning module MTU-105 (represented in the plane MP3-9331), and that one between pressure

transducers and system is provided by the conditioning module MCU (represented in the plane MP3-9322).

The monitoring equipment is intended to offer necessary information regarding the operation condition of the cooling batteries. The system architecture allows centralizing the information in the control room, on the equipment display and on the monitor of a computer dedicated to monitoring.

The equipment functions are assigned as follows:

- temperature measurement and monitoring by means of thermoresistive probe;

-pressure measurement and monitoring by means of piezoelectric or Pitot tube transducers;

-measurement and monitoring of velocities by means of the hot wire anemometer type transducers

-calculation of: pipe sections, flow rates, heat flows at oil circuits and air circuits, cooling efficiency;

-permission to control the cooling batteries when oil temperature imposes it;

-transmission of signals for alarm/disconnection of the transformer unit when oil temperature exceeds pre-set thresholds;

-transmission of alarm signals when the normal values of the monitored parameters are exceeded;

-permission to display and send remotely different input quantities or quantities calculated by means of analog outputs;

-permission to visualize, in a centralized manner, the quantities on the monitor of a computer intended for monitoring, located in the control room;

-permission to record the monitored parameters at programmable time intervals.

Hardware structure of the central unit. Description of component parts

The block diagram of the central unit has the configuration from Fig.1 and is designed unitarily for the oil cooling circuit and air cooling circuit.

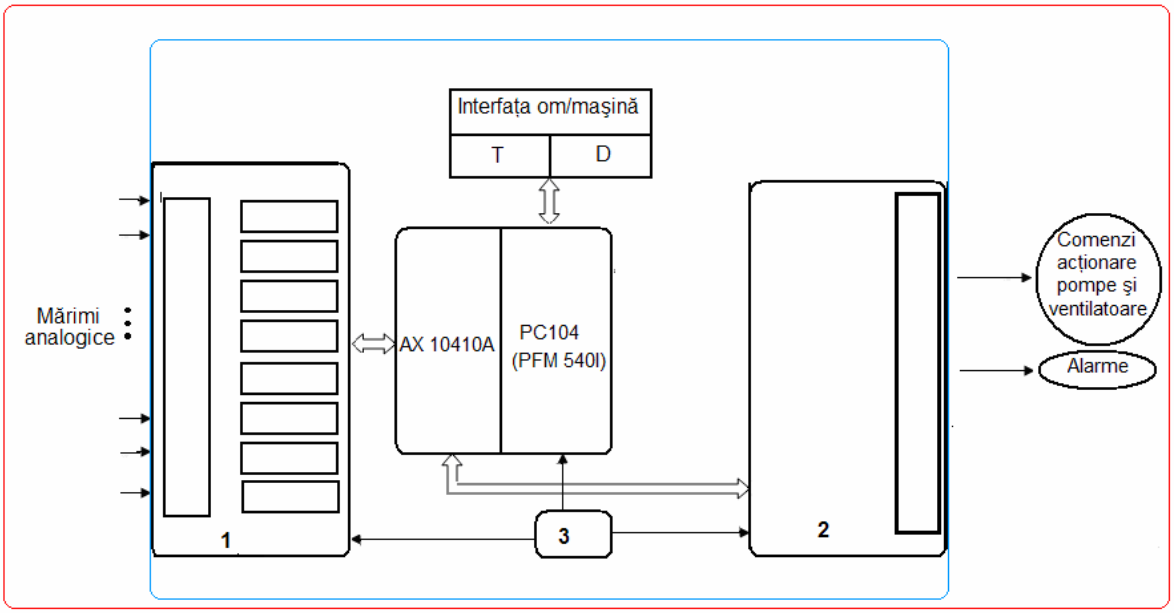

Fig.1. Block diagram of the monitoring equipment
1- analog input interface, AX10410A – module for processing the analog and digital quantities, PC104 – central unit with microprocessor, T – keyboard, D – alphanumeric display,
2– digital output interface, 3 – source plate

The component modules of the equipment have been designed and achieved for facilitating the specific function implementation, on condition that the electromagnetic compatibility is assured in high voltage substations.

Activity II.2 Elaboration of documentation for the functional model of the monitoring system for air cooling circuit

The cooling medium is the environmental air which, in a pneumatic circuit, is drawn in by the electric fans from the vicinity of the tank walls and forced to make a heat exchange, washing the external walls of oil radiator.

The heat flow taken over by the secondary heating medium – ventilated air

$$\Phi_a = Q_a \cdot \rho_a \cdot c_{pa} \cdot (t_a' - t_a'') + 10^{-8} \cdot \varepsilon \cdot c_0 \cdot S_u \cdot [T_m^4 - T^4],$$

according to the mathematic model established in the previous stage of the project implies the real time measurement of air current temperature and velocity parameters.

The air temperatures at the battery radiator input and output, also the environment temperature are read by means of temperature sensitive resistor type transducers. As regards the air flow velocities necessary for calculating the air flow rates Q_a at the fan output , reading can be done by the hot wire anemometer type transducers.

Air characteristics, like density ρ_a, specific heat at constant pressure c_{pa}, are taken from technical literature and presented under a tabular form, depending on temperature.

The hardware structure of the monitoring system for the air cooling circuit is represented similarly to that one for the oil cooling circuit, in the plane MP1-9326, and the component characteristics are according to the technical specification.

The interface between temperature transducers and system is provided by the conditioning module MTU-105 (represented in the plane MP3-9331), and that one between velocity transducers and system is provided by the conditioning module MCU (represented in the plane MP3-8322).

The constructive characteristics of the cooling battery, also the nominal diameter of oil pipes, fan suction/discharge diameters, are entered by the operator from the keyboard.

At the end of the work, for systematizing the results, by using the Excel basic functions (Math & Trig ; Logical ; Database, Information) of the program Office Excel 2007, tables and own functions have been created, according to the application requirements. These systematized results will help us in the future activities of the project, in developing software in programming languages like C^{++}, Visual Basic, Matlab, etc.