

## **Stage II.2 - Elaboration of documentation for the functional model**

### **Stage objectives**

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

- Activity II.3 Development of software package for acquisition, processing and cooling system monitoring
- Activity II.4 Development of software for implementing the theoretical method for analytical calculation of thermal field of the cooling system

### **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.

The activities (II.3 and II.4) presented further on are complementary to the activities (II.1; II.2) presented in a previous stage, and together they complete the objectives of stage II- elaboration of documentation for the functional model.

### **Activity II.3 Development of software package for acquisition, processing and cooling system monitoring**

The monitoring software is a desktop application, used for assessing the efficiency of the cooling batteries related to the power transformers from substations. It runs on MS Windows and allows an accessible presentation of the data in especially designed windows, also the storage of the acquired data in text files and EXCEL.

The following functions are provided:

- On-line data displaying;
- System data displaying;
- Creation of reports for stored data;
- System operation simulation.

The application is developed in C+ and Visual C languages. The application is run on Microsoft WINDOWS XP SP3.

The application is a complex and complete environment for visualizing the specific parameters of a cooling battery, having a rate for parameter updating of maximum 10 seconds, taking into account that the monitored parameters are slowly varying parameters

The possibility to visualize simultaneously the parameters of a cooling battery, also the visualization of the condition of the cooling batteries related to a transformer unit was taken into account.

Configurare unitate de transformare pentru statia electrica configurata

Configurati unitatea de transformare pentru statia electrica configurata

Nume unitate de transformare	.....
Producator	.....
Serie	.....
Anul PIF	.....
Tensiune primara	.....
Tensiune secundara	.....
Curent primar	.....
Curent secundar	.....
Putere nominala	.....
Numar baterii de racire	.....
Tip baterii de racire	.....
Tip radiator	.....
Tip pompa	.....
Diametru nominal	.....
Debit nominal	.....
Tip ventilator	.....
Diametru nominal	.....
Debit nominal	.....

Portul serial folosit pentru comunicatia cu aceasta unitate de transformare: COMM 1

Viteza de comunicatie asociata portului serial folosit: 57600 b/s

SALVEAZA MODIFICARILE      IGNORA MODIFICARILE EFECTUATE

The constant quantities of the application, also the variable quantities picked up from the process are stored in program subroutines. The calculation software referring to the heat flows for oil circuits and air circuits, also the efficiency of the cooling process are created in C<sup>+</sup>.

```

prog - Notepad
File Edit Format View Help
Bateria de răcire nr.....
Circuitul de răcire al uleiului
su=(3.14*du^2)/4;
// Sectiune conducta ulei su: [m^2]
tu=(t_prim_u+t_secund_u)/2;
// Temperatura medie a uleiului din bateria de racire tu: [Grad kelvin]
Ro_u(tu)=1041.8-0.6*tu;
// densitate ulei Ro_u(tu): [kg/m^3]
vu=sqrt(2/Ro_u(tu))*Pd;
// viteza uleiului la iesire din bateria de racire vu: [m/s]
Qu=vu*su;
// debit ulei prin bateria de racire qu: [m^3/s]
Phi_u=Qu*Ro_u*cpu*(t_prim_u-t_secund_u);
// Flux termic cedat de ulei din bateria de racire Phi_u: [kw]

Circuitul de răcire cu aer
sa=(3.14*da^2)/4;
// Sectiune aspiratie ventilator sa: [m^2]
n=1;
n=2;
n=3;
Phi_a=n*va*sa;
// Debit aer ventilator/ventilatoare Phi_a: [m^3/s]
ta=(t_prim_a+t_secund_a)/2;
// Temperatura medie a aerului de racire ta: [Grad kelvin]
tr=(tu+ta)/2;
// Temperatura medie a peretelui radiatorului bateriei de racire tr: [Grad kelvin]
Phhi_a=Qa*Ro_a*cpa*(t_secund_a-t_prim_a)+ 1.0000e-008*Eps*Co*s*(tr^4-ta^4);
// Flux termic preluat de aerul de racire Phhi_a: [kw]
// Eficienta racirii
Phi_u=Phhi_a, OK
if Phi_u > phhi_a then Alarmare + Diagnoza
if tu < tuprag then
    OK
//tuprag=378 grd Kelvin(85 grd Celsius)
else Alarmare + Diaagnoza

```

#### Activity II.4 Development of software for implementing the theoretical method for analytical calculation of thermal field of the cooling system

Within the power transformer, similarly to electric circuit, a thermal circuit can be mathematically described and modeled by a relation as:

$$P = C_{th} \frac{d\vartheta}{dt} + \frac{\vartheta - \vartheta_{amb}}{R_{th}}$$

So, the insulating oil temperature at the top of the transformer  $\theta_{ulei}$ , also at the bottom zone  $\theta_{i,ulei}$  can be calculated.

For an **efficient cooling**, there are attempts to keep as small as possible the difference between  $\theta_{ulei,m}$  (measured oil temperature) and  $\theta_{ulei,c}$  (calculated oil temperature). If the measured temperature is always higher than the calculated temperature, one should verify if the thermal resistance  $R_{th}$  decreased as compared to the nominal thermal resistance  $R_{thn}$ , thus checking if there is a problem with the cooling system (cooler pollution, pump or fan failure) .

If the transformer overloading is intended, an incipient heating should be assured, for avoiding a too sudden increase of temperature. The optimal correspondence between the transformer losses and the power required for cooling should be assured. The measured/calculated losses are compared with the cooling system power, achieving the automation of the cooling system depending on this difference (if the losses are higher, it means that a cooling unit should be started; otherwise, it should be stopped.)

Having the top oil temperature and bottom oil temperature calculated, the power which needs to be dissipated can be calculated:

$$P_{TH} = c_{ulei} \rho_{ulei} \Psi_{ulei} [\theta_{s,ulei} - \theta_{i,ulei}],$$

where:  $P_{TH}$  – is thermal power which should be dissipated,  $\psi_{ulei}$  – oil flow rate [ $m^3/s$ ].

This power is compared to the rated power ( $P_{THn}$ ) and we will have an image of the cooling: if the calculated value is lower than the rated one, it results there is a problem with the cooling system (cooler pollution, pump or fan failure).

The monitoring software “E Monitor” is a desktop application, used for the monitoring-diagnosis of power transformers from substations.

The application was developed in the programming environment Microsoft Visual Studio NET 2005, programming language Visual BASIC. It runs on the system Microsoft WINDOWS Xp SP2. The data base server used for storage is My SQL 5.0

The monitoring software “EMonitor” is a desktop application, used for the monitoring-diagnosis of power transformers from substations. It runs on MS Windows and offers an accessible presentation of the measuring data, many combinations and zoom possibilities, and together with the application EStocare offers also a visualization of

historical data and alarms.

For instance, if the emphasis of certain thermal duty of the transformer is intended, the button “thermal duties” is accessed, and if the acquired quantities are used, a duty similar with that one presented further on is got:

