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EDITOR :	JOSE MANUEL HERNANDEZ
VERIFIED BY :	
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CONTENTS

0. OBJECTIVE OF THE FUNCTION 1

1. FUNCTION ENVIRONMENT 1

2. INPUT DATA DEFINITION 2

3. DYNAMIC BEHAVIOUR 3

4. DATA PROCESSING (ALGORITHMS) 3

5. INTERFACES 4

5.1 OPERATOR INTERFACES 4
5.2 SYSTEM INTERFACES 4

6. ERROR MANAGEMENT 4

7. CONSTRAINTS 5

8. HARDWARE AND SOFTWARE REQUIREMENTS 5

9. TEST PLAN 5

0. OBJECTIVE OF THE FUNCTION

The objective of the function is to calculate and report the dissipated energy in any of the refrigeration coils of the plant. This way we can calculate the real heating of the item under observation, independently from the incoming water flow and temperature.

For this purpose, we will define the model that describes the relationship between the water flow inside the coil, the temperature variation the water suffers and the resulting dissipated energy.

1. FUNCTION ENVIRONMENT

The function will evaluate the level of heating in any coil. So, the information presented to the user contains the dissipated energy computed by means of the model.

This evaluation will be executed every time the input data described below is selected from SCADA sensors by the monitoring system, and will use the most recent data collected by the instrumentation in real time. The results obtained from the execution of the function will be stored into the real-time DB.

The sequence of requests and responses of the function is the following:

Event	Request/Response (RQ/RS)	From	To
Monitoring Request	RQ	Function	Function
Collect Data (continuous extern function with a fixed sample interval)	RQ	Function	Data Acquisition System (D.A.S.)
Data Collected (continuous function with a fixed sample interval)	RS	Data Acquisition System (D.A.S.)	Data Base
Select Data (on monitoring request)	RQ	Function	Function
Data Selected (on monitoring request)	RS	Data Base	Function
Perform Monitoring	RQ	Function	Function
Store Results (dissipated energy)	RS	Function	Data Base

2. INPUT DATA DEFINITION

The different system of the plant where this model will be applied are:

- **stator** air refrigeration coils
- **generator upper carter** oil refrigeration coil
- **generator lower carter** oil refrigeration coil
- **turbine carter** oil refrigeration coil

For each refrigeration coil the input data will be:

Q: water flow in coil (analogic, m^3/s, missing by SCADA).
TURB_GB_COIL_WAT_FLOW (Pelton)
TURB_GB_COIL_WAT_FLOW (Francis)
UGB_COIL_WAT_FLOW (Pelton)
UGB_COIL_WAT_FLOW (Francis)
STAT_COIL_WAT_FLOW (Pelton)
STAT_COIL_WAT_FLOW (Francis)
LGB_COIL_WAT_FLOW (Pelton)
LGB_COIL_WAT_FLOW (Francis)

note:
The Q values are not gathered in SCADA system but there are local sensors.

T_{WI} : water inlet temperature (analogic, °C, SCADA).
XA-V0210 STAT_COLD_WATER_TEMP (Pelton)
XA-V0207 STAT_COLD_WATER_TEMP (Francis)

note:
T_{WI} has the same value in all refrigeration coils

T_{WO} : water outlet temperature.
XA-V0212 STAT_COIL_WAT_OUTLET_TEMP (analogic, °C, SCADA). (Pelton)
XA-V0209 STAT_COIL_WAT_OUTLET_TEMP (analogic, °C, SCADA). (Francis)

LGB_COIL_WAT_OUTLET_TEMP (analogic, °C, missing by SCADA) (Pelton)
LGB_COIL_WAT_OUTLET_TEMP(analogic, °C, missing by SCADA) (Francis)
UGB_COIL_WAT_OUTLET_TEMP(analogic, °C, missing by SCADA) (Pelton)
UGB_COIL_WAT_OUTLET_TEMP(analogic, °C, missing by SCADA) (Francis)
TURB_GB_COIL_WAT_OUTLET_TEMP(analogic, °C, missing by SCADA) (Pelt)
TURB_GB_COIL_WAT_OUTLET_TEMP(analogic, °C, missing by SCADA) (Fra)

note :
Water outlet temperatures in carter coils are not gathered in SCADA but there are local sensors in generator carters

Output data definition

The output of this function will be used to estimate the probability of a future malfunction in any of the parts whose operation depends on the working of the coils (stator, generator upper and lower carters, turbine carter). So, we want to estimate the quantity of heat dissipated in each one of them:

For each refrigeration coil the output data will be:

a) result of the function calculations
- Dissipated energy (analogic, kW).

b) Input data:
-Q : water flow in coil (analogic, m^3/s).
-T_{WI} : water inlet temperature (analogic, °C).
-T_{WO} : water outlet temperature (analogic, °C).

c) system conditions:
-T_{AI} : air inlet temperature (only for stator air refrigeration coils) (analogic, °C, SCADA).
XA-V0211 STAT_HOT_AIR_TEMP(Pelton)
XA-V0208 STAT_HOT_AIR_TEMP(Francis)
-T_{AO} : air outlet temperature (only for stator air refrigeration coils) (analogic, °C, SCADA).
XA-V0211 STAT_COLD_AIR_TEMP(Pelton)
XA-V0210 STAT_COLD_AIR_TEMP (Francis)
-T_O : Oil temperature (only for carter oil refrigeration coils) (analogic, °C, SCADA).
XA-V0204 TURB_GB_OIL_TEMP(Pelton)
XA-V0201 TURB_GB_OIL_TEMP(Francis)
XA-V0206 LGB_OIL_TEMP(Pelton)
XA-V0203 LGB_OIL_TEMP(Francis)
XA-V0209 UGB_OIL_TEMP(Pelton)
XA-V0206 UGB_OIL_TEMP(Francis)

3. DYNAMIC BEHAVIOUR

As mentioned in section 1., the function will make some simple calculations to transform the initial data selected from the D.A.S. So, the function will be executed when retrieving data from SCADA by the monitoring system, and the results stored into the real-time DB.

4. DATA PROCESSING (ALGORITHMS)

In this section we will define the model used to determine the dissipated energy in a coil. The dissipated energy is calculated multiplying:

1. The water flow (Q l/s)
2. The water density (1 Kg/l)
3. The water specific heat (4,2 kJ/kg ºC)
4. The temperature difference between inlet and outlet water flow:

Dissipated Energy:

Ed (kW) = Q (l/s) ∗ 1 (kg/l) ∗ 4,2 (kJ/kg ºC) ∗ [T_{WO} - T_{WI}] (ºC)

5. INTERFACES

5.1 OPERATOR INTERFACES

The operator interfaces will be the same of those relative to monitoring tasks, since the result of this function will be used in monitoring tasks.

The implementation of this function can be done in C or C++.

The simulation of the system for testing purposes can be done easily by including in the D.B. some historical incident data.

5.2 SYSTEM INTERFACES

The system interfaces are the input and output data specified above.

6. ERROR MANAGEMENT

- Input data into normal limits (T_{WO} >= T_{WI} + H_{MIN}).
- Control software errors (overflow, division by zero).
- To discard abnormal input values (deviation from the mean)
- Control null values or not existent (for a given period) in B.D.
- Control result values (not negative, for example).
- Errors must be included in separate files/tables, identified by a key and containing error type.
- All kind of error signals from the computer must be captured in the function.

7. CONSTRAINTS

The only real-time constraint is the availability of data in the D.B. for the chosen period of time. This means that the process for the data gathering from the sensors must insert data into the D.B. almost continuously (with a sample rate to determine).

8. HARDWARE AND SOFTWARE REQUIREMENTS

C,C++ (Borland), Oracle, PC architecture, Windows-NT.

9. TEST PLAN

The testing of this function will be specified in the WP6 IBERDROLA documents for the Adaptation and Experimentation Specifications of the System.

Among other features the following will be tested:

- Control of incorrect input data/input data format.
- Values by default.
- To prove that the resulting values keep into normal limits ($Ed >= Ed_{MIN}$).
- Control of limit values.