Aspects of the heating medium voltage bus bars, from power plants and power stations

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Abstract: The paper proposes to conduct a case study on the heating medium voltage bus bars which enter in the configuration of stations and electrical posts. Taking into account the effects which may be generated by heat collector bars is required prophylactic permanent monitoring of this phenomenon.
Key-Words: Beam collector, Medium voltage, Contact resistance, Stations and electrical posts, Thermal effect.

1 Introduction
Starting from the way to build the busbar systems (single, double, triple), one can see that their path is made of several segments, connected by means of screws. Given the importance of control resistance which is set between the segments joints busbars, preventive checks are required at a certain time, and the results recorded in the form of features. Following the time evolution of the bus bars heating phenomena of stations and transforme posts, you can prevent emergency regimes and simultaneously providing electrical power quality parameters supplied to the consumers connected to the busbars. Given these issues, the paper is based on an appropriate stage of the heating phenomenon busbars for two sectors which enter in the configuration of “Electrical Minestation” (Fig. 1) arranged in the the lab stations and posts of the Faculty of Engineering of University Constantin Brancusi Tg-Jiu.

Pass the cage through an electrical circuit elements will cause excessive dilatation, which if exceeded the limits of elasticity can lead to permanent deformation or abnormal games. Bars and wires can reach their melting and the neighboring elements (insulators) can achieve complete destruction. The heating rods can lead to oxidation of the surface they contact and increased contact resistance, so an increase in voltage drop between the areas leading to local heating and energy loss in the final destruction of conductive elements. Isolation from heating elements can be destroyed either due to expansion forces or due to chemical transformations that can occur due to warming. Could shape and an overall structure that includes most components of a monitoring system parameters (especially temperature) of the collector bars (Fig. 2).
2 Study Heating Process Bars Collectors

In Romania was adopted as the ambient temperature limit to be considered about $\theta_0=40^\circ$C. Temperature which can reach an electrical installation for a normal operation ($\theta_n$) is given by the sum of ambient temperature and overheating ($\tau_n$) to the environment according to the relation [1]:

$$\theta_n = \theta_0 + \tau_n$$  \hspace{1cm} (1)

where $\tau_n$ is the overheating temperature, ambient temperature $\theta_0$.

Equilibrium is achieved when the amount of heat received by the collector bars is equal to the amount of heat transferred to the environment. The appearance of a cage, because the current rapid growth is no longer respect the equality before the heat that occurs due to current passing through the element and heat environment that yields the surface element. This rapid increase in current leads to an adiabatic temperature rise which conductive elements can melt. If after leaving the system short circuit collector bar system remains offline, it will cool to ambient temperature and if it returns to normal operation will be cool to an appropriate temperature according to Fig. 3.

Under current rules by which the temperature can incălzii bar depending on the material it is made is for Al=200 °C and for Cu=300 °C. In case of short circuit protection which acted after eliminating it, or if the cage is extinguished, the temperature variation is shown in Fig. 3a, where $\theta_k$ is the temperature at the time of fire or short-circuit interruption, $\theta_n$ is the nominal temperature of the operating bars, $\theta_0$ is the atmospheric temperature, $t_1$ is the time measured from when the short-circuit by stopping the arc in the breaker, curve 1 is the corresponding short-circuit fire and the curve 2 corresponding to the interruption of short-circuit.

Fig. 2: The general pattern of monitoring equipment parameters collector bars.

Fig. 3: Changes in temperature during a short circuit collector bars after discontinuation:
  a) Explanation
  b) purchased.
current extinction. To avoid destruction of the plant the appearance of short circuit current will require a large reduction of the duration of short circuit to avoid heating due to short-circuit current passage [2-4]. This method is universally adopted, because it requires a larger than smaller, covering only overheating of the time until the interruption of current through the circuit. If short circuit is extinguished by itself, but is interrupted by circuit protection, time to stop will be:

\[ t = t_p + t_1 = 0.045 \text{ [s]} \]  

where \( t \) is time to stop a current through the circuit, \( t_p \) is the time of referral by the protection of short circuit current (\( t_p = 0.025 \text{ s} \)) and \( t_1 \) is time to drive the contactor.

### 3 Determination of the thermal effect on the Bar of Medium Voltage

To determine the effect of heat on medium voltage bars will go from the heat balance relation [11]:

\[ c \cdot m \frac{\partial \theta}{\partial t} = \lambda \frac{\partial^2 \theta}{\partial x^2} + q(x,t) - \frac{k(x,t)}{S_x} p_x (\theta - \theta_0) \]  

(3)

Specific losses due to current passage unit time are determined by the relationship:

\[ q(x,t) = \frac{r t^2}{\theta} = \rho \frac{d_x}{S_x} \frac{1}{S_x} i^2 = \rho \left( \frac{i}{S_x} \right)^2 = \rho \sigma^2 \]  

(4)

Replacing lost motherland and loyalty to specific equation (3) we obtain:

\[ c \cdot m \frac{\partial \theta}{\partial t} = \lambda \frac{\partial^2 \theta}{\partial x^2} + \rho \sigma^2 - \frac{k p}{S} (\theta - \theta_0) \]  

(5)

The steady equilibrium is achieved when \( \theta = \) constant, then \( d\theta/dt = 0 \). In this case, the equation of equilibrium will be:

\[ \rho \sigma^2 = \frac{k p}{S} (\theta - \theta_0) - \lambda \frac{\partial^2 \theta}{\partial x^2} \]  

(6)

Will be considered the bar will have a constant temperature along the length \( (\partial^2 \theta / \partial x^2 = 0) \) and then the heat balance equation is:

\[ c m \frac{\partial \theta}{\partial t} = \rho \sigma^2 - \frac{k p}{S} (\theta_n - \theta_0) \]  

(7)

\[ \theta - \theta_0 = \frac{\rho S}{k p} \sigma^2 - \frac{c m S}{k p} \frac{\partial \theta}{\partial t} \]  

(8)

Solving differential equations obtained and considering \( \rho, k \) and \( c \) constant heat equation under various bar sector is:

\[ \theta_n - \theta_0 = \frac{\rho S}{k p} \sigma^2 \left[ 1 - e^{\frac{-kp}{\rho \sigma^2}} \right] \]  

(9)

Considering the heating adiabatic heat balance equation for the relative small considering all the heat supplied bar serves only to increase the temperature, we obtain:

\[ c m \frac{\partial \theta}{\partial t} = \rho \sigma^2 \Rightarrow \frac{\partial \theta}{\partial t} = \frac{\rho}{c m} \cdot \sigma^2 \]  

(10)

Depending on rated current value of the bars will cause the bar diameter and its section. For a collector bar with nominal voltage of 110 kV will be:

\[ d = 12.34 \text{ mm} \]

\[ S = \pi \frac{d^2}{4} = \pi \frac{2.34^2}{4} = 120 \text{ [mm]} \]  

(11)

The bar is the Cu chosen and can carry current \( I = 921.7 \text{ [A]} \). It will read the tables and diagrams and thermodynamic ventilation [4] solid, liquid and gas density, specific heat and heat transfer coefficient on the bar with:

\[ \rho = 2710 \text{ [kg]} \]

\[ \lambda = 236 \text{ [W/0C]} \]

\[ c = 902 \text{ [J/kg0C]} \]  

(12)

Depending on the temperature rise speed of the bars collector current density is determined for each rod in hand, according to Tab. 1.

<table>
<thead>
<tr>
<th>( \sigma ) [A/mm²]</th>
<th>10</th>
<th>20</th>
<th>50</th>
<th>100</th>
<th>200</th>
<th>500</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \frac{\partial \theta}{\partial t} ) [°C/s]</td>
<td>0.5</td>
<td>2</td>
<td>12.5</td>
<td>50</td>
<td>200</td>
<td>1250</td>
</tr>
</tbody>
</table>

Tab. 1: Current density for each bar.

Short-circuit current density for the selected section will be:

\[ \frac{\partial \theta}{\partial t} = 4S^0 \text{ C} \]  

(13)

It will return to the simplified heat balance equation to calculate the temperature of the bars after the trigger switch time [12]:

\[ T = 0.05 \text{ [s]} \]

\[ i^2 R dt = c \cdot M \cdot d\theta \]  

(14)
short-circuit temperature rise is relatively high, and therefore they will take into account variations in resistance and specific heat against temperature.

\[
R_0(1+\alpha \theta) = \rho_0 \frac{I}{s} (1+\alpha \theta) \\
c = c_0(1+\beta \theta) \\
M = m l s
\]

(15)

Will result in the following form of balance equation:

\[
\frac{l}{S^2} \int_0^t i^2 dt = c_0 \frac{m}{\rho_0} \frac{1+\beta \theta}{1+\alpha \theta} d\theta
\]

(16)

Integrating over the interval \((t)\) of short-circuit and the initial temperature and final \(\theta_i\) and \(\theta_f\) we obtain:

\[
\frac{l}{S^2} \int_0^t i^2 dt = A(\theta_f) - A(\theta_i)
\]

(17)

where:

\[
A(\theta) = \frac{m C_0}{\rho_0} \left[ \frac{\alpha - \beta}{\alpha^2} \cdot \ln(1+\alpha \theta) + \frac{\beta}{\alpha} \cdot \theta \right]
\]

(18)

Initial temperature \((\theta_i)\) and final temperature \((\theta_f)\) curves are selected graphs presented in Fig. 4. Since the integral \(\int_0^t i^2 dt\) is relatively difficult to calculate because of the complex variation of short circuit current time we use a practical method of calculation, namely, thermal equivalent current method. This method is based on a thermal equivalent current \(I_e\) that if it passes through a bar in a time of one second would produce the same heating effect as the actual short circuit current in real time.

\[
\int_0^t i^2 dt = I_e^2 \cdot t
\]

(19)

Thermal equivalent current is determined using the following expression:

\[
I_e = I^{*} \cdot \sqrt{(m+n) t}
\]

(20)

where: \(m=f(k_{shock}, t)\) is a factor that depends on aperiodic component of short circuit current and is determined from Fig. 5 and \(n=f(I/I_{\infty}, t)\) - is a factor dependent periodic component Short-circuit current and is determined from Fig. 6.

Provided that the electrical plant collector bar system to be stable short-circuit is given by the following inequality:

\[
I_e^2 I^{*} \leq I_{1t}^2 t_{1t}
\]

(21)

where: \(I_{1t}\) is current thermal limit, and \(t_{1t}\) is time thermal limit.

![Fig. 4: Temperature variation for different materials](image)

![Fig. 5: Curves \(m=f(K_{shock}, t)\)](image)

![Fig. 6: Curves \(n=f(I/I_{\infty}, t)\)](image)

Given the characteristics as shown in Fig. 4, the copper collector bars at ambient temperature of 40 °C we choose [13-15]:

\[
A(\theta_0) = 0.35 \cdot 10^4
\]

(22)
To solve the integral using the method we obtained by calculating the thermal equivalent current value of short circuit current \( I \) the following values:

\[
\begin{align*}
    \frac{I}{I_0} &= 1.5 \\
    I &= I_n \times 1.5 \\
    I' &= 24052619
\end{align*}
\]  

From the curves of variation of coefficients \( m \) and \( n \) presented in Fig. 5 and Fig. 6 for a period of one second we choose the following values:

\[
\begin{align*}
    m &= 0.1 \\
    n &= 0.7
\end{align*}
\]

Depending on the values chosen for the coefficients \( m, n, k_{\text{shock}} \) and \( I'/I \), the thermal limit current will be:

\[
\begin{align*}
    I_{\text{el}} &= 24052619 \times 0.1 + 0.7 \\
    I_{\text{el}} &= 21513316 \\
    \int_0^t i^2 dt &= I_{\text{el}}^2 + I'
\end{align*}
\]  

To determine the final temperature permitted collector bars we use the relations:

\[
\begin{align*}
    A_0 &= \frac{1}{S^2} \int_0^t i^2 dt + A_{0f} \\
    A_0 &= \frac{1}{S^2} x I_{at}^2 + A_{0f} \\
    A_0 &= \frac{1}{120^2} x 21513316 \times 10^2 + 0.35 \times 104 \\
    A_{0f} &= 180.46
\end{align*}
\]

Final temperature of the copper bar will be collecting around values of 94 °C.

Block diagram of the equipment acquisition temperature in extended version is illustrated in Fig. 7. Optical fiber transmission system using optical transmission circuits (converters Optoelectronic RS232/FO) and reception through mediation a fiber optic environment. A system for transmitting information on optical fiber, offers several benefits not found in systems with copper conductors (immunity to electromagnetic interference and radio from the damaging effects of lightning, no closing loop of parasitic currents through circuits ground, flexible network topologies.

**4 Conclusions**

The paper shows the negative effects of heat-collecting medium voltage bars falling in the pattern of electric power plants and power stations and making a concrete determination of the current strength as a study conducted specifically on two areas of collector bars interconnected with one another through a switch longitudinal torque.
ordered from a PC using a data acquisition boards.

In case study conducted in the work emphasized that to avoid destruction of the plant the appearance of short circuit current resulting from a scheme to short circuit will limit the time of such scurcircuit be a correlation between the time the trigger of the power switch current limit and thermal bar system supported by collectors.

Implementation of data acquisition, is a novelty in the control circuit of medium voltage switches, making the connection between the computer processor and switch actuating device of longitudinal coupling. The eight outputs of the purchase card may take command switch from a distance by computer but also can be accessed starting an automatic backup Operate a feed a simulation can be achieved between the two bar collectors set.

References