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COMPUTING SYSTEM FOR INDUSTRIAL CORROSION MONITORING

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GENERAL

As a part of the past inheritance and due to the unfulfilments recorded during the transition period, so far, the present energy utilization in Newly Associated States (NAS countries), including Romania, are practically more behind those used in EU countries.
The additional consumptions per unit product which are recorded in NAS countries versus the average level of the EU countries are between 10-40%.

Also, that means important energy leakages, high level of noxious emissions and high „contributions" to GHGs effect., high quantity of waste waters and high extend of corrosion efect with negative influence of environmental protection (acid rains, as a direct influence of sulphur content emissions are catastrophals for ecosystems).

Taking into account the United Nations Conference for Environment / Rio de Janeiro 1992 and Framework Convention on Climate Change / Kyoto Protocol referring to the implementation of the 27th Principle of the State and people willingness to cooperate in an „entante cordiale" concerning the environment protection/energy efficiency, this project is a very good example in this respect, having high contribution to the fulfil by NAS countries of the **acquis communitaire.**

The European Commission has adopted a Communication on "The regional dimension of the European Research Area", where awards would be given to less favoured regions, particularly in candidate countries.
In this respect, this project represent a contribution to the Integration of the NAS technical-scientifically and technological community in ERA-European Research Area.
The CLEAN COMBUSTION concept for the Thermal Power burning process market, is convergent with the following desideratums:

- Energy losses mitigation/energy efficiency increasing;

- Noxious emissions reduction;
- Corrosion effect limitation;

The add value of **computing system for industrial corrosion monitoring** consists on the following aspects:

- The fulfilment of the third desideratum dedicated to CLEAN COMBUSTION – CORROSION EFFECT LIMITATION-for Thermal Power Plants.
- To the end of the project, it will be offered a Low Cost hardware and software System, that will constitute an on-line corrosion advisory subsystem for the operators and managers.
- The system, unlike classic systems using corrosimeter equipments, has the advantage that using **Expert SYSTEM** function [consisting of one **Cognitive System / Information Basis, Specific Algorithms** and **Optimising Algorithms**] will have an important predictive component, helping the plant operators in a professional preventive maintenance
- the system will assure, a good correlation between burning parameters, like energy losses, burning efficiency, excess air, acid and water dew points, noxious emissions-SO_2, SO_3, NO_X, CO, CO_2 , etc.
- the life increasing of the flue gases ducts and of the low temperature heating surfaces (economizers, air heaters) with approx. 30%.

EXPERT SYSTEM FUNCTION

This function gives an important predictive maintenance component of the system consist of the **Cognitive System / Information Basis**, **Specific Algorithms** and **Optimising Algorithms.**

The **Information Basis** will consist of technological / technical characteristics, necessary technological specific parameters, existing diagrams, graphics, tables, burning general thermodynamic.

The **Specific / Developing Algorithms** are dedicated to achieve [using equations, graphical mathematical visualizations, interrelation between different burning thermodynamic parameters] real time / full up to date. technological process corrosion panorama.

The **Optimising Algorithms**, using advanced search mechanism, will calculate optimum values-and optimum interrelation- for corrosion specific parameters and will give suggest values for the set points of the control loops in direct connection with low-temperature corrosion.

PROCESS ANALYSYS

Low-temperature corrosion occurs on the heating surfaces of economizers, air heaters and flue gases ducts, which operate at relatively low temperature of the gases and working fluid (air).

The decisive factor in intensive low-temperature corrosion is the presence of sulphuric acid vapors in the flue gas flow, for the boilers with coal and/or heavy oil fuel.

With a certain surplus of air, SO_2 further oxidized to SO_3 by atomic oxygen.

$SO_2 + O'' = SO_3$

In the zones where the gas temperature drops down below 400^0C, SO_3 begins to react with water vapours and forms sulphuric acid vapours which are carried by the flue gases flow.

The process is completed at a temperature near 200^0C.

Corrosion of the heating surfaces (economizers, air preheaters, flue gases ducts) starts if the temperature of the wall and the boundary layer at the wall turns out to the below the condensation point of water vapours of sulphuric acid, at their partial pressures in the gases.

The temperature at which moistures condensed on a solid surface is called the thermodynamic dew temperature (dew point) $t_{d.p.}$

For fuel oil combustion, the dew point can be roughly determined from the formula:

$t^{s}_{d.p.} = t_{d.p.} + 250(S^rO_2)^{1/2}$, where

$S^r = S^w/Q_l^w$ is the resolved sulphur content of fuel, %Kg/MJ, and $O_2 = 21(\lambda-1)/\lambda$ is the concentration of surplus oxygen in the gas flow.

With a higher sulphur content of fuel and higher excess air ratio λ, more SO_3 forms in gases, resulting in a higher dew point.

Corrosion of the metal occurs in the presence of a condensed liquid film containing H_2SO_4 on the metal surface; it continues further when new quantities of H_2SO_4 are supplied from the flue gases flow; thus, the rate of corrosion is proportional to the condensation rate of H_2SO_4 vapours.

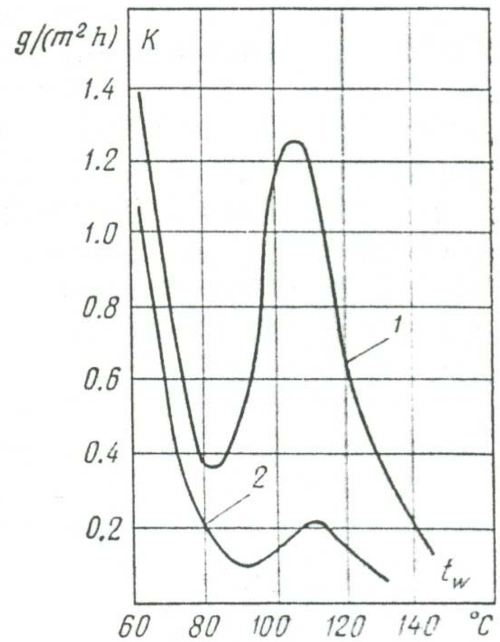

Fig. 1 Effect of temperature on the corrosion rate
in packing sheets of regenerative air heater

1 - high excess air ratio in combustion chamber ($\alpha_f \leq 1.1$);

2 - lowest allowable excess air ratio ($\alpha_f = 1.02 – 1.03$);

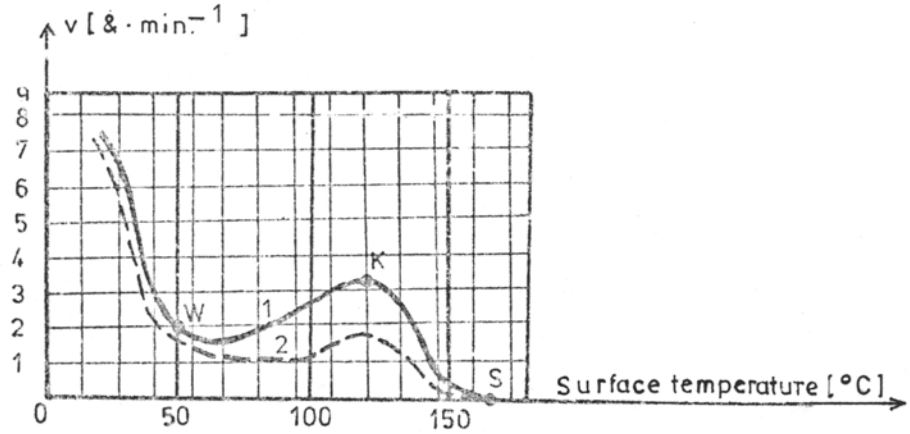

Fig. 2 The film corrosion moulding speed
1- Film moulding speed [Å*min.-[1]]
2- Corrosion [mg * m^{-2} * n^{-1}]
S- acid dewpoint
W- water dewpoint
k- corrosion dewpoint

Figure 1 shows two typical corrosion curves to different temperatures on low - temperature heating surfaces in contact with the flue gases; the rate of corrosion varies non-monotonically with the wall temperature (t_w); as t_w decreases from the dew point (approx. 145^0C) corrosion first increases sharply to a maximum at t_w=105-110^0C, then falls off steeply and finally, at temperature of the wall below 80-90^0C, there is a second rise in the rate of metal corrosion.

The rate of corrosion in the temperature range of 80-120^0C decreases substantially at a decrease in the excess air ratio (curve, 2 Fig.1) which is associated with a less intensive formation of SO_3 and H_2SO_4 vapours in the flue gases in that temperature range

To avoid low-temperature corrosion, it is essential that t_w to be higher sulphuric dew point.

For low temperature corrosion appearance, are decisive (**Fig.2**) heating surfaces different exterior temperature and the thickness of the liquid condensed layer, named **corrosion film moulded speed.** In figure 2 are showed corrosion film moulded speed and corrosion curves (after. K. Jankinson).

To the flue gases cooling, appears corrosion film to the acid dew point (point S).

Corrosion film moulded speed increases with cooling until a first maximum (point K) named corrosion point.

To the continuously flue gases cooling, corrosion film moulded speed first decreases and then increases very strong after water dew point (W).

The lowest allowable temperature on the surfaces of a tubular air heater and flue gases ducts can be determined and will be also used in mathematical corrosion modelling.

Within the project will be developed and put into operation methods for corrosion control in low temperature heating surfaces and flue gases duct, including control working temperature of the metal surface, monitoring of the water and acid dew points, monitoring of the excess air ratio and inlet combustion air temperature.