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Experimental Determination of Temperature Control Maps in the Case of Coking Chamber

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Abstract

The most important experimental data in the case of the coking chamber's functioning is the value of the metallic wall's temperature, T, which is distributed according to the coking chamber's height, h, and to the percentage of time from the coking cycle. These temperature control maps are determined from experimental measurements, realized during the chamber's working, using temperature sensors (thermocouples). These sensors have a role of control of the process evolution and give the possibility of a real-time temperature measurement.

Key words: *coking chamber, experimental measurements, control maps*

Theoretical Considerations

The coked petroleum residues result from a complex thermal process, characterized by a transient temperature field, which mathematical description is very difficult, because in the coking chamber a multiphase system (gas-liquid-solid) is formed during that processes. This formed system is continuously modifying its composition, volume and temperature. More than that, the cyclic operation of the coking chambers doesn't do anything else other than complicate the thermal field's description. The thermal field is determined by: the raw material flow's input temperature and by the raw material's hydrodynamic flow in the chamber, by the coking cycle and, also, by the weather conditions. A certain influence on the thermal field is given by the raw material's quality.

In order to obtain some qualitative data, absolutely necessary for the study of the coking chambers` thermal field, there were undertaken many experimental tests on several coking chambers in operation [1], [3].

For example, in figure 1 are presented the functioning parameters during a coking cycle.

The Experimental Model and Data Processing

The most important factor which determines the coke's quality is the amplitude and the variation's character of the metallic wall's temperature. This factor has an appreciable influence on the stress level that occurs in the coking chamber's body.

Industrial experimental research, made on the operating coking chambers, gave the possibility to realize some control charts for the temperature's control during the entire coking cycle. Those charts were realized using appropriate statistical processing of obtained data.

The control charts are a graphical mean for analysis that can be developed and easily used in service conditions. They give also the possibility of an efficient qualitative and quantitative evaluation of the introduction in the current practice of some technological and constructive solutions that aim both the production quality and the safety increase during working.

In case of an insufficient knowledge of the laws of variation of coking processes` parameters, it is indicated the use of control charts for variation of the parameter's mean value (mean temperature, in this case) and its deviations.

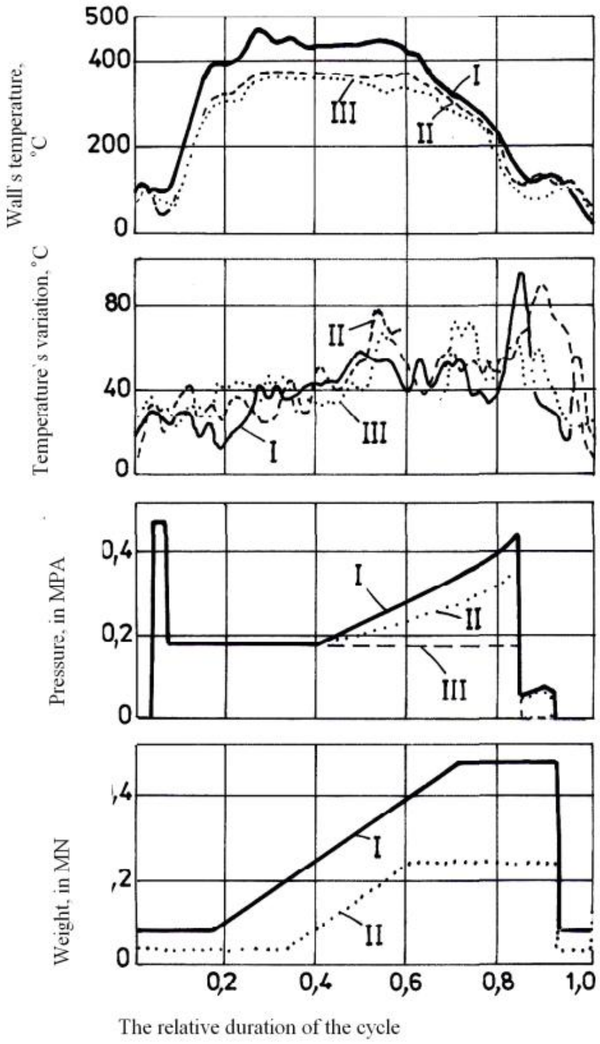

Fig. 1. Functioning parameters during a cycle [1]

Being one of the essential input data in creating the finite element simulation, this law of variation is determined using experimental measurements made during equipment's operation, by using temperature sensors (thermocouple). The mounting of these sensors on the metal wall of the coking chamber, protected by thermal insulation, is provided by design (according to production drawings and assembly drawings), having the role of a good control of the technological processes` evolution and enabling real-time measurement of temperature.

In figure 2 at the coking chamber's level, where the raw material is transformed into coke, (on the sections I and II, figure 3), seven transducers are mounted (Tr1, .., Tr7), mentioning that a first transducer Tr1 is situated at the joint R3 level, considered to have the height 0, and the transducer Tr7 is mounted at the free surface of the liquid found at the R8f joint's level [5].

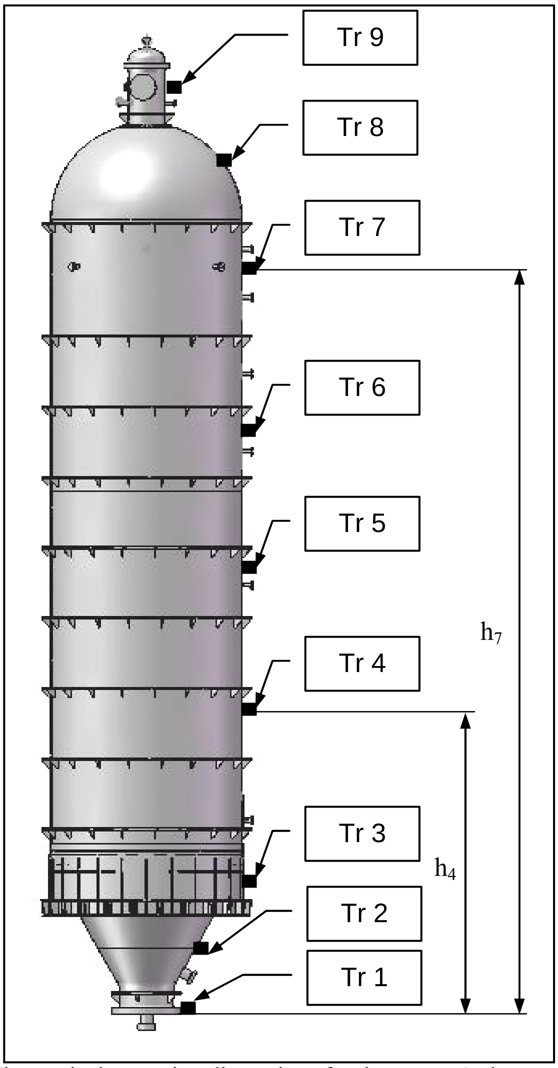

Fig. 2. The vertical mounting dimensions for the sensors` placement

There are still two transducers mounted in the upper zone of the coking chamber, one on the exterior surface of the spherical bottom (Tr 8), and the other on the dome's surface (Tr9). Height dimensions of the transducers` mounting are shown in table 1.

Table 1

Tr_k	h_k [mm]	Tr_k	h_k [mm]
Tr 1	0	Tr 6	12800
Tr 2	700	Tr 7	21650
Tr 3	3500	Tr 8	24500
Tr 4	7600	Tr 9	27500
Tr 5	9500		

The use of these thermocouples permits the determination of a database which links the temperature (T) to the relative duration of the coking cycle (*P* means "percent") and to the coking chamber's inner height (*h*). In figure 3 is presented the temperature's variation of the chamber's wall versus its height and coking cycle, meaning the temperature control maps.

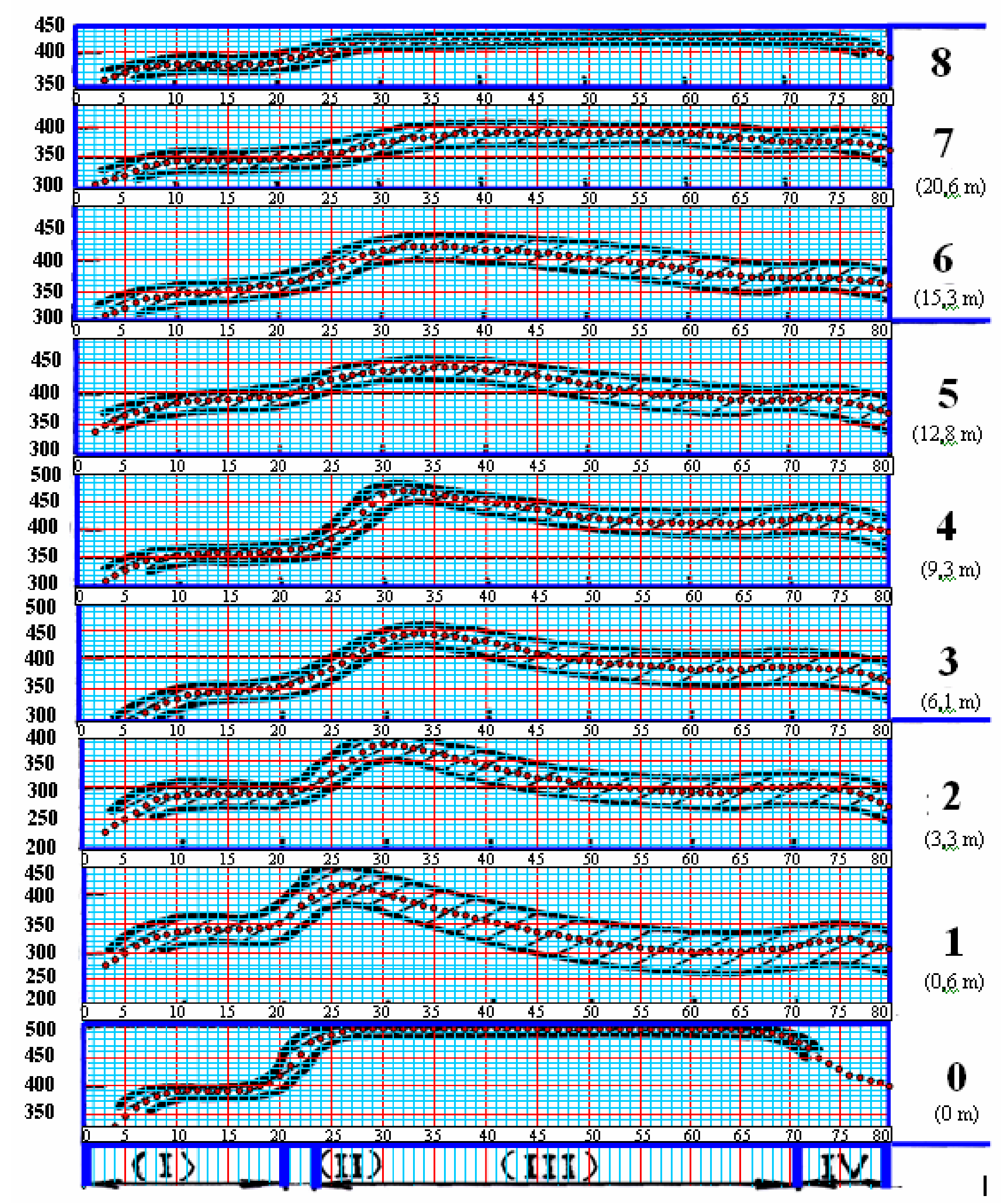

Fig. 3. The experimental measurements of a coking cycle: the temperature control maps.

After the analysis of the recorded data, there were obtained the mean values of the temperatures, depending on the percentage *P* of coking cycle and of the height *h*.

It results an experimental confirmation of the fact that differences in temperature occur, between the maximum values and the minimum ones, contained in a range of values (50… 100)°C, in case of the experimental measurements of a coking cycle (see hatched area in the graphs T (P, h), in figure 3).

Depending on the height, the coking chamber is divided in three sections: I, II, III (see figure 1), which are also divided, each one of them, in eight zones (0…8).

Depending on the relative duration of the coking cycle, there were determined four periods of time (I… IV).

In the first part of the cycle, the temperature is insignificant; so, the diagram is not made for this part. One can highlight that at the level of a given section (zones 0…8) may occur temperature differences between 50^0 C and 100^0C; these are presented in figure 3, by the hatched areas.

At the inferior part of the coking chamber, in section I, namely, a gradual warming of the metallic wall occurs, when the preheated raw material is introduced. Then, during the period of time I, the temperature reaches the values` floor of $(300\ldots\ 350)^0$C; is the initial stage of the coking, seen in terms of location and time.

In the section II, the second stage of the coking is developed; it is the zone in which there are recorded the biggest thermal decomposition temperatures, where the strongest coke is formed. We specify the relatively high duration of the maintaining of these temperatures, the periods II and III, respectively.

In the section III, there are developed lower temperatures, because of the fact that the raw material's flow loses its heat by passing through the coke quantity already formed in section II. Also, it is the peak area which loses the heat to the exterior environment, being surpassed the filling zone with technological material.

The thermal field of the coking chamber's surface is not homogeneous; this fact can be very well observed in the conical reduction zone (0-1), where the temperature's gradient has values of 100^0C…150^0C on section.

In the middle zone, the temperature's differences shrink, the thermal field is homogenized. But in the zones 4-5 from the superior part, at (9…12) m, several temperature oscillations are present, due to the foaming phenomenon and due to the final thermal decomposition.

Conclusions

The coking chamber has been considered the best example for the creep phenomenon's study, associated with the thermal oligocyclic fatigue.

The most important input data for the Finite Element Method programs, in this case of a coking chamber, is the value of the temperature in the metallic wall, *T*, which is distributed depending on the chamber's height h and the time percent of the coking cycle *P*. So, there was conceived a calculus program using the interpolation method, with the help of the third order Spline Functions, which establishes the numerical expression *T(P,h)* function, and it is recognized by the program in its mathematical form [5].

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Determinarea experimentală a harților de control a temperaturii în cazul camerei de cocsare

Rezumat

Cea mai importanta data experimentala, în cazul camerei de cocsare, este valoarea de temperatură a peretelui metalic, T, care este distribuita în funcție de înălțimea camerei de cocsare, h, precum şi de procentul de timp al ciclul de cocsare. Hărțile de control ale temperaturii sunt determinate din măsurători experimentale, realizate în timpul de lucru al instalatiei, prin utilizarea senzorilor de temperatură (termocuple). Acesti senzori au rolul de control a evoluției procesului şi dau posibilitatea de măsurare a temperaturii în timp real.