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THE APPLICATION OF HEAT FLOW SENSOR TO STUDY THE HYDRATION OF INORGANIC BINDERS

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ABSTRACT

In studying the rate of heat evolution during the hydration of binder samples a sheet differential multicouple was used. Its application can be exemplified by hydration of aluminous and Portland white cement mixtures.

INTRODUCTION

The setting and hardening of inorganic binders is a complicated hydration process associated with heat evolution. The time dependence of heat evolution has been studied calorimetrically .
In this paper, the application of comercial heat flow sensor for quasiisothermal calorimetry will be described. Both the simple contruction and assembly are suitable for common plant practice. As an example of utilization may serve the results obtained from measuring heat evolution for the hydration of mixtures aluminous /AC/ and Portland white cement /PC/, respectively.

EXPERIMENTAL AND RESULTS

The heat flow sensor is made on the principle of a differential multicouple; thermoelectric joints are located by turns along both sides of insulating sheet. A futher thermocouple for the surface temperature determination is built in the sheet 1 . The sample holder with the weight sample / 1 - 5 g/ of binder is laid on the sensor. Both the sensor and the sample are in perfect contact with a metal block, i.e. heat sink ensuring the removal of hydration heat. The heat sink has a high thermal conductivity and thermal capacity of order two times higher than that of the sample.

The heat flow sensor is calibrated by producer[x] in $W.m^{-2}$units.

The required amount of tempered water is injected in the sample by a stainless capillary.

The output signal of sensor was registered by the line recor-

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der TZ 4 100 / Labora,ČSSR/ and digitally by means of microvoltmeter MT 100 / Labora, ČSSR/ containing the built-in A/D converter, which enables the on-line processing of data by computer.

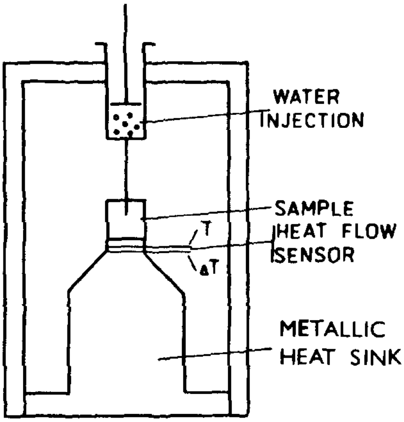

Fig. 1 Calorimeter assembly

The short distance of both the measuring and the reference joints within the sheet differential multicouple is advantageous. Due to this fact the demands for the exact thermostating of reference junctions are decreased. A high resolution of superimposed thermal effects developed in a very short time interval has been achieved. On the other hand, the disadvantage lies in the relativaly lower intensity of output signal; it can be enhanced either electronically or by choice of the thicker insulating sheet in the sensor production.

The suitability of calorimeter assembly was verified during the investigation of hydration processes / at 21 °C/ of Gorkal aluminous cement, Portland white cement / Ceva, ČSSR/ and their mixtures, respectively /Fig.2,3/. The calorimetric curves for cements are of the characteristic shapes having an initial exoterm in the earlier minutes of hydration. The induction period and the second maximum of heat liberation, arising after 3.5 /AC/ to 13.5 hour interval /PC/, follow. The addition of one cement to another is resulting in:

i/ The intensity increase in the first peak. By the analysis of the peak shape the two maxima are found, i.e. the most pronounced ones for the mixture of AC/PC = 7/3.

ii/ The time shortening taken to reach the second maximum of heat evolution to such a degree that, for instance, for the mixture of AC/PC = 1 and 3/7 it coincides with the first peak. Simultaneously, the peak intensity is increased.

Variations ascertained in the rate and time for the maxima of thermal effects may be ascribed to the interaction of Ca^{2+} ions from PC to hydrating $CaAl_2O_4$ from AC. Of great significance is

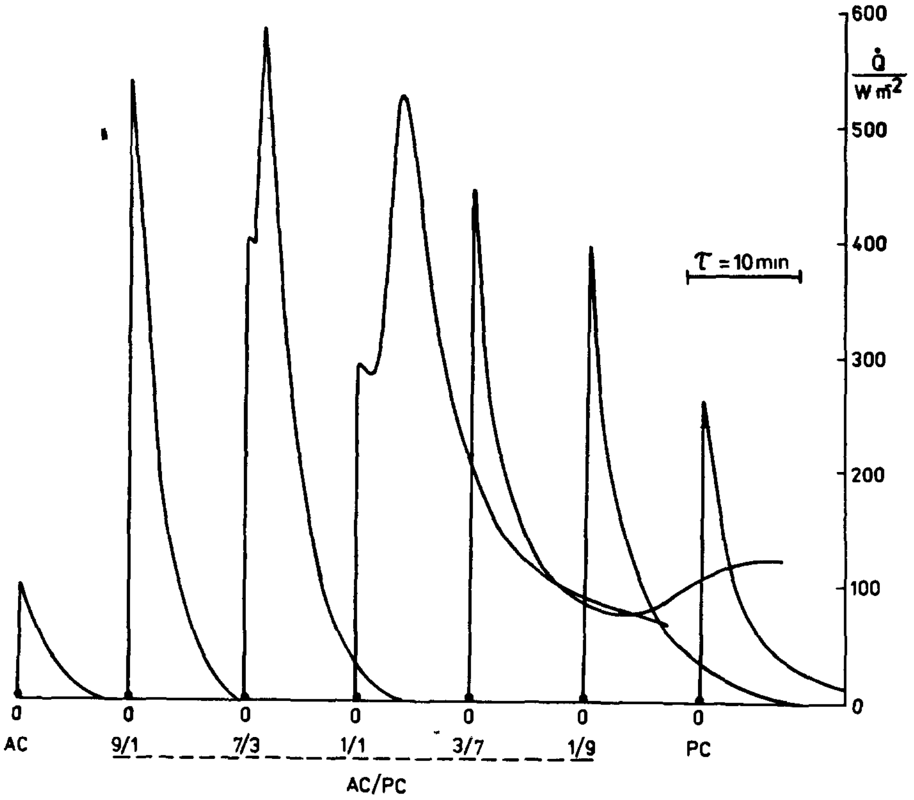

Fig. 2 Influence of aluminous/Portland cements ratio on the calorimetric curve (the first 10 minutes)

also the interaction of hydrosilicates formed with hydroaluminates. This results in succesive changes of the phase composition of hydration products depending on the mixing ratio. In addition to typical hydration products, the presence of gehlenitehydrate / $2CaO.Al_2O_3.SiO_2.8\ H_2O$/ in the mixed hydrated binders has been proved, which is in accordance with Cottin's study shown in ref. 2 . The hydration of cements is seen as being controlled by diffusion of water and solute species through protective colloidal gel coatings precipitated at very early stages around the cement grains. The rate of hydration depends on the permeability and cohesion of these coatings. Modification of the colloidal gel to a more open flocculated structure facilitates diffusion and accelerates hydration, what is the case of hydrating AC/PC mixtures.

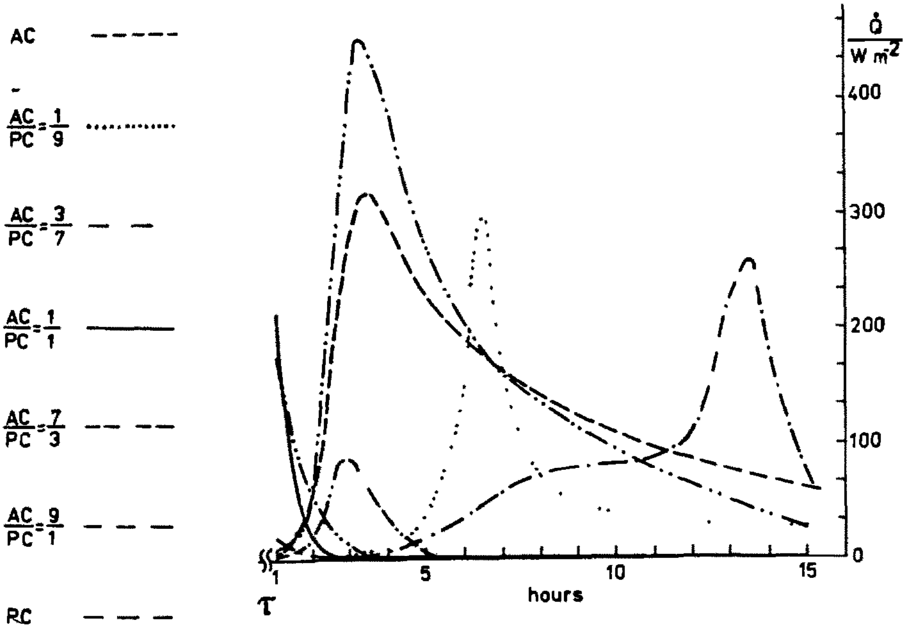

Fig. 3 Calorimetric curves of hydrating cement mixtures (since 1 to 15 hours)

From the results presented it follows that one cement has, with regard to another, a character of setting accelerator. The influence of accelerators and retarders on setting may be properly controlled by means of conduction calorimetry.

SUMMARY

The applicability of simple equipment with the heat flow sensor was confirmed by evaluating the admixtures influence on the course of hydration of aluminous/Portland cements mixtures.

REFERENCES

1 Patent ČSSR No. 125 515 with patents pending in several foreign countries
2 B.F. Cottin, Hydration des Mélanges Silicates - Aluminates de Calcium, Proc. VIIIth Int. Conf. Cem. Chem., V - 113, Paris 1980