Thermochimica Acta, 135 (1988) 341–345
Elsevier Science Publishers B.V., Amsterdam

APPLICATION OF DIFFERENTIAL THERMAL ANALYSIS IN THE INVESTIGATION OF MOULDING SANDS

E.DOBIEJEWSKA
Institute Building Technology of the Technical University of Wrocław, Poland

ABSTRACT

On the basis of the DTA curve of clay binders it has been proved that it is possible to predict certain technological properties of quartz-clay moulding sands. Among these properties there are compression strengths, thermal durability and determining the maximum temperature of the treatment process.

Casting moulds are produced from quartz-clay moulding sands which consist of quartz sand, clay mineral and water. The strength of moulding sands depends mostly on clay minerals such as kaolinite and montmorillonite (bentonite) clays. Bonding strength of those clays is in turn dependent on their water absorption capacity (coefficient δ) . The value of δ is related to clay structure, ion exchange type and binder dispertion degree. The dependence of the amount of water absorbed by various binders on time is shown in Fig.1 [1,3].

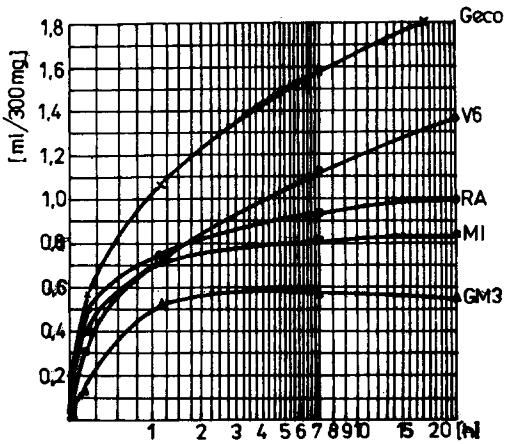

Fig. 1. Water absorption capacity of various clay binders.

The highest value of σ is that of chemically activated Geco bentonite, then go V6, Milowice (Ml), Radzinków (Ra) bentonites and GM3 clay. Values of green strength R_c^w diminish in the same succession. Under constant value of clay-to-water ratio K it is equal to 0.18 MPa, 0.11 MPa, 0.08 MPa, 0.07 MPa and 0.04 MPa for Geco, V6, RA, Ml and GM3 binders respectively. Those significant differences in water absorption capacities of clay binders as well as the differences in their compression strengths can be determined from DTA curves (Fig.2) [1,2].

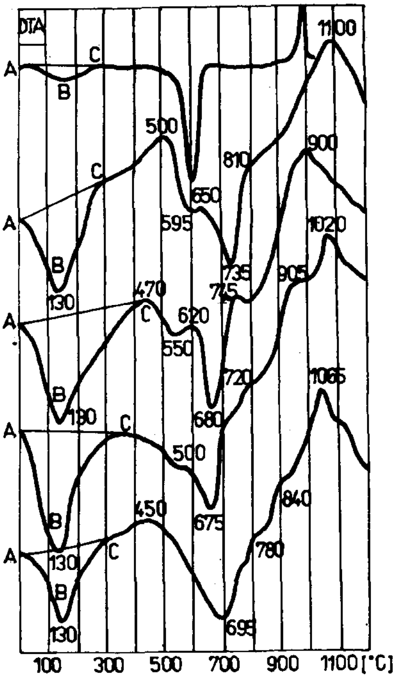

Fig. 2. DTA curves for various clay binders.

Apart from the identification of the types of minerals those curves can also be used for determination of the percentage of the main constituents (such as kaolinite and montmorrillonite) of tested material. Grain-size distribution and crystallization degress of tested material can also be determined from those curves.

DTA curve within the temperature range of 20-350 °C represents the endothermic dehydration reaction. Hygroscopic and interlayer water removed in that temperature range. The area ABC under DTA curve corresponds to the amount of heat used up for dehydration. It is also related to the water absorption capacity of the binder. The greater this area the greater the water absorption capacity δ (cf. Fig.1 and Fig.2) [4]. Since it has been shown that the greater the coefficient δ (under constant water-to-clay ratio K) the higher the strength of a moulding sand, the method of differential thermal analysis can be applied for the evaluation of technological properties of binders. Suitability of a binder for preparation of moulding sand can be quickly assessed on the base of the first endothermic peak of DTA curve. This assessment is additionally made easier by taking into account the value of mass losses connected with water removal. They vary from 0.8% for kaolinite binders to 4.5% for sodium bentonites. In short, basing on the value of the area ABC under DTA curve and on the binder mass loss the types of moulding sands that may be prepared from a binder under testing can be initially selected. That is why more than 10% of a binder with small ABC area and only 5-8% of a binder with large ABC area is applied under water-to-clay ratio K = 0.3.

DTA curve can also be applied in testing of moulding sands for the assessment of the effect of temperature on the variation of bonding properties of binders [4]. Those properties depend on thermal durability. Thermal durability of a binder is in turn related to its rehydration capacity. The variation of the value of coefficient δ with two hours roasting temperature is shown in Fig.3.

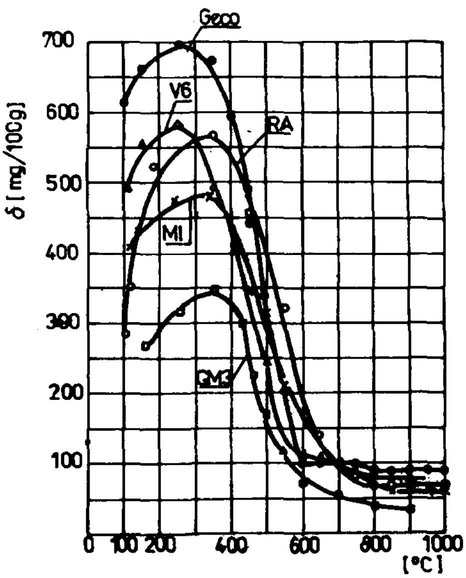

Fig. 3. Effect of roasting temperature on water absorption capacity of various clay binders.

It follows from the investigation that the higher the water absorption capacity and the higher the binding properties of a binder the lower the temperature at which the value of σ is maximum. For Geco and V6 bentonites this temperature is up to 250 °C, while for M1, RA and GM3 bentonites it amounts to 320-350 °C. Those temperature values should not be exceeded when processing and activating clay minerals to be used as moulding clay binders.

Differential thermal analysis can also be used to explain the effect of carbon and carbon-forming additions on thermal durability of binders. As shown in Fig.4, the addition of oil to the binder results in the fact that thermal peak does not disappear in spite of temperature having been increased by 100 °C.

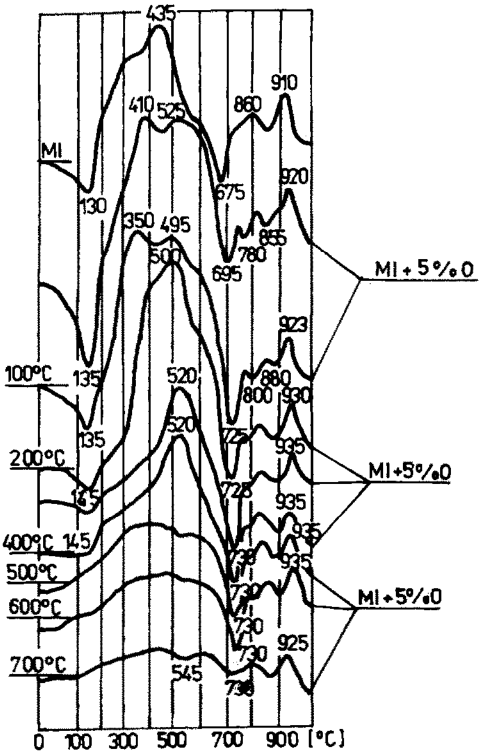

Fig. 4. DTA curves for M1 binder with oil addition as depended on roasting temperature.

Moreover, the maximum of thermal peaks is shifted by 8 °C towards higher temperature region. This "stabilization" and temperature shift of thermal peaks results in higher thermal durability of the binder accompanied by an increase in compressive strength as depended on roasting temperature (Fig.5). In effect the addition of fresh binder for circulating sand rebonding can be limited.

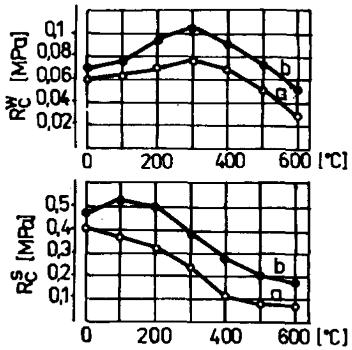

Fig. 5. Compressive strength R_c^w of green moulding sands vs roasting temperature.
a) quartz-clay moulding sand
b) quartz-clay moulding sand with oil addition.

CONCLUSION

Usability of the method based on differential thermal analysis in the investigation of moulding sands is presented. The method can be used for:
- determination of water absorption capacity of clay binders
- determination of bonding properties of clay binders and their thermal durability
- determination of the effect of special additives (e.g. carbon and carbon-forming materials) to quartz-clay moulding sands on their properties as depended on temperature
- determination of allowable temperature of clay binder treatment processes.

REFERENCES

1 E. Dobiejewska and H. Gumienny, Przegląd Odlewnictwa 1(1970) 7
2 E. Dobiejewska and H. Gumienny, Prace Naukowe IIBM,Pol.Wr. Studia i Materiały 1 (1970) 3 .
3 E. Dobiejewska and H.Gumienny, Prace Naukowe ITBM Pol.Wr. Studia i Materiały 1 (1970) 33.
4 E.Dobiejewska and A.Micker, Przegląd Odlewnictwa 5 (1976) 117
5 E.Dobiejewska and A.Micker, Przegląd Odlewnictwa 1 (1978) 260