

# Eighth International Ceramic Congress

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THE Eighth International Ceramic Congress was held in Copenhagen during 21-25 May 1962 under the presidency of Dr Erik Lindgren. The congress was attended by about 1000 participants representing 29 countries. Thirty-nine papers were presented at the congress, of which 9 were from Germany, 8 from France, 7 from Great Britain, 3 from Italy, 2 each from Austria, U.S.A. and U.S.S.R., and one each from Canada, Czechoslovakia, Holland, Sweden, Switzerland and India. A notable and interesting feature of the congress was a number of works visits in Denmark and Southern Sweden. These included visits to laboratories and mechanized factories producing refractories, glazed sewer pipes, clinkers, heavy clay products, electrotechnical porcelain, wall tiles, earthenware and porcelain.

The scientific deliberations of the congress were divided into four sections (number of papers given in parenthesis): Basic science (11); Refractories (11); Heavy clay (10); and Pottery (7).

## Basic Science

The first paper by N. F. Astbury and F. Moore (Great Britain) pertained to the study of plasticity of clays. From studies on the cyclic stressing of clay bars in torsion, the manifestation of the phenomenon of hysteresis has been established; the loops obtained with shear stresses up to 200,000 dynes/sq. cm. have been found to be non-elliptical. The dependence of the loop area on moisture content and the nature of the clay mineral has also been studied. C. Brosset (Sweden) reported that in the systems  $\text{Cs}_2\text{O-SiO}_2$  ( $\text{Cs}_2\text{O}$  4-11 per cent) and  $\text{BaO-Na}_2\text{O-SiO}_2$  ( $\text{Na}_2\text{O}$  5-6 per cent and  $\text{BaO}$  3-30 per cent) it is possible to determine the Cs-O and Ba-O distances from the radial distribution curves; a value of 4.1 Å. has been obtained in several cases. The results indicate that alkalis and alkali earths enter a silicate glass as relatively well-defined groups which in turn occupy defined regions of the original  $\text{SiO}_2$ -glass. L. Cartz (Great Britain), G. Mollenstedt (Germany) and A. Septier (France) reported that the microstructure of ceramic materials can be studied at temperatures above 1000°C. using the thermionic emission electron microscope and at room temperature using the bombardment emission microscope. A simple thermionic emission electron microscope was described and its application in

sintering studies and in the measurement of diffusion coefficient was discussed. J. Debras-Guedon and I. A. Voinovitch (France) reported that on the basis of certain special properties, 8-hydroxyquinoline (oxine) is an ideal reagent in the analysis of silicates by flame photometry. The reagent increases the specific emission of each element and is particularly useful in the case of elements which are not easily excited. It also suppresses certain interferences of a chemical nature, particularly those resulting from dissociation reactions. In the presence of oxine, small quantities of Ca and Sr could be determined (0.10 per cent CaO and SrO) in the presence of large amounts of alumina (c. 40 per cent). Flame photometric estimation in the presence of oxine has also been applied to the determination of Al, Fe, Ca, Mg, Na, K and Li in silicates. P. E. Glaser (U.S.A.) pointed out the advantages of using optical systems to concentrate radiation from a heat source for the study of high temperature phenomena. A technique for the measurement of thermal conductivity of small samples at high temperatures from 1000°C. up to their melting points was described. A new apparatus for growing single crystals was reported and its use in zone refining described. The use of shutters to simulate the effect of heat pulses for the study of surface characteristics of materials was described. R. Goton's (France) paper was concerned with the study of fused oxides. Microexamination of fused oxides has shown that certain mixtures of oxides have, in the liquid state, a vitreous structure in which are enclosed the nuclei responsible for final crystallizations. The reactions taking place on controlled devitrification of these glasses in the solid state have been studied by differential thermal analysis. P. S. Keeling (Great Britain) presented evidence in support of the existence of a continuous series of clay minerals from well-ordered to disordered kaolinite (livesite) extending to illitic clays. A clay mineral can be represented by a continuous modification of kaolinite lattice in which the emplacement of divalent cations in the octahedral position is accompanied by a reduction in the number of hydroxyl ions, a concept which offers a simple and coordinated explanation of ceramic properties. W. Mann (Germany) reported the results of studies on the millability of five types of abrasives, viz. brown regular aluminium oxide,

light-green silicon carbide, white special aluminium oxide, dark-green silicon carbide and boron carbide using a ball mill. The influence of milling time and milling intensity on the crushing resistance of different abrasives has been studied on the basis of screening analysis done with the mechanically operated Rotap apparatus. The results obtained on the nominal grain residue and crushing resistance of different types of abrasives indicate that the ball mill method represents a satisfactory procedure for the determination of the crushing resistance of abrasive materials. According to H. Saalfeld (Germany),  $\text{Al}_2\text{O}_3/\text{Ni}$  needle-like crystals are formed during the production of cermet at *c.* 1700°C. in the presence of water vapour. The lattice constants of the crystals are:  $a = 7.591$  Å.,  $b = 7.675$  Å. and  $c = 2.876$  Å. Patterson and Fourier synthesis shows the crystals to have a sillimanite structure. F. Scholl (Germany) discussed the application of elution and frontal gas chromatographic methods in obtaining adsorption isotherms and determining the absorption energy of a solid surface. A relationship has been shown to exist between the shapes of the adsorption isotherms and the elution and frontal chromatograms. N. A. Toropov, I. A. Bondar and F. J. Galakhov (U.S.S.R.) stressed the importance of the study of complex systems formed by silicates of the rare earth elements in the production of high temperature ceramic materials. X-ray and other physico-chemical studies of systems containing silicates of rare earth elements show that these silicates are distinguished by extremely high melting points. For example, systems formed by oxyortho- and ortho-silicates melt in the temperature range 1750-2000°C. and those formed by diortho-silicates in the range 1700-1800°C.

### Refractories

F. Bischoff (Germany) reviewed the work on the origin, decomposition and characteristics of dolomites carried out during the last ten years. The thermal decomposition of dolomite to 'half-burned' dolomite and to other products like soft, hard and dead burned dolomites was described. P. P. Budnikov (U.S.S.R.) presented results of studies on the use of silicon carbide to increase the resistance of mullite and corundum refractories to spalling. The refractories obtained by adding carborundum and a binding refractory clay to mullite and electrocorundum have been found to be suitable for floors of coke oven chambers, recuperator blocks, saggars and muffles, parts of decks of tunnel kiln cars and also for such uses where a high temperature and resistance to spalling of the refractory are needed. G. Grungo and M. Dalmazzo (Italy) gave a general

description of the passage kilns used for firing ceramic material, with particular reference to the properties of refractories employed. The metamorphic phenomena of some refractories under specific conditions were discussed. The factors contributing to the corrosion of refractories were enumerated and suggestions on the properties of refractories necessary for use in passage kilns were given. G. Grungo, A. Gisondi and M. Rattazi (Italy) reported the results of chemical, physico-technological and petrological studies on the siliceous refractories prepared from different kinds of quartzites using increasing amounts of CaO. It has been shown that the free CaO content is inversely proportional to the firing temperature. Findling-quartzites have been found to react more easily with lime than those of fels.

F. Kieseewetter (Austria) discussed the merits of the system of mathematical evaluation of test data in the refractories industry. L. Lecrivain (France) reported that in the case of an aluminosilicate refractory prepared under high pressure, a close correlation exists between the fluctuations in the different mechanical properties (bending strength, crushing strength, tensile strength and modulus of elasticity). The fluctuations can be determined by measuring the rate of propagation of vibration in the test piece. This test has the advantage of being non-destructive and more precise than the classical tests. The influence of the gas atmosphere on the performance of clay bonded SiC refractory materials formed the subject of the paper by S. Lukacks (Germany) and H. Abrecht (Switzerland). The argon atmosphere has been found to have a very detrimental influence on the technological properties of SiC refractories as it promotes the formation of SiO. Flue gases containing carbon monoxide are slightly oxidizing and affect the refractory material to a negligible extent. Simultaneous addition of silicon metal and graphite improves the technological properties of the SiC refractory and they give satisfactory performance in the presence of all types of gas atmospheres. G. R. Rigby (Canada) gave a general review of the various test methods applicable to basic refractories. The most important tests are resistance to thermal shock and resistance to molten slags. The importance of using full-size bricks in certain tests was stressed. The author discussed the possible modifications in test procedures during the next few years. H. E. Schwiete (Germany) reviewed the methods currently in use in Germany for measuring the resistance of refractory materials to thermal shock. Comparative results obtained by destructive method of measuring the decrease of eigenfrequencies after the individual

chillings, and by other methods were presented. V. Tomanek (Czechoslovakia) described three new laboratory tests for determining the homogeneity, maximum refractoriness-under-load and resistance against slagging of refractory and schistous clays. These tests have been used for the comparative evaluation of the suitability of refractory clays for the manufacture of grog. J. D. Walton and N. E. Poulos (U.S.A.) reported that massive and complex objects could be fabricated from fused silica employing a casting slip made from fused silica, or combining it with coarser fused silica aggregate. The bodies obtained were reported to retain excellent thermal shock resistance, dimensional stability at elevated temperatures and electrical and nuclear properties of the clear fused silica. Such fused silica objects could be successfully used under conditions where devitrification would cause clear fused silica to be useless. The most outstanding properties of slip cast fused silica are: (i) low specific gravity (1.9 g./ml.); (ii) low thermal conductivity ( $8 \times 10^{-4}$  cal./sq. cm./°C./sec./cm.); (iii) low coefficient of thermal expansion ( $0.54 \times 10^{-6}$  cm./cm./°C.); (iv) low drying and firing shrinkage (1-1.5 per cent total); (v) low thermal stable dielectric constant (3.18 at  $10^{10}$  c/s.); (vi) low loss factor (0.0002 at  $10^{10}$  c/s.); and (vii) absence of warping due to thermal gradients.

### Heavy Clay

L. Alviset and C. Liger (France) described two different methods of maintaining clays in a state of equilibrium during drying. M. Boutry (France) suggested the use of colliers shales as a lean fuel in the brick body for heavy clays. The manufacturing process using these scales involves: (i) drying the raw grains emerging from the coal washery, (ii) crushing the dry grains, (iii) mixing the powder obtained in the presence of water in a central type batch weighing concrete mixer, (iv) rapid drying by flue gases arising from the ignition stage of the products during firing, and (v) firing in a Hoffmann or a tunnel kiln, the latter permitting only self-firing or maximum economy in fuel. For every ton of fired products, 130-150 therms of heat energy and 35 kWh. of electrical energy are required. The output possible is 5 tons per man per day. P. Daignaud and M. Aveline (France) have studied the influence of the method of filling the mould on the quality of dry pressed stoneware bodies obtained (moisture 7.75 per cent) using an ultrasonic method. It has been shown that the method of feeding does not have the same influence on the texture of the bodies obtained as on the distribution of pressure.

R. T. Laird and H. T. S. Swallow (Great Britain) outlined the measures to prevent the occurrence of lime blowing in the products obtained from a large brickwork. H. Pechmann (Austria) presented the results of studies on the relative fire resistance of different types of structures. It has been found that prestressed ceramic constructions show higher resistance during the fire tests than prestressed reinforced concrete constructions. P. Leusden (Germany) explained the process occurring in the 'external' friction of clay on steel as contrasted to the laws of its 'internal deformation'. For this measurement, clay was forced through cylindrical tubes of different lengths and diameters. Both methods of measurement characterize the flow behaviour of clays and give the relevant physical constants. The resistance against flow characterizes the resistances to the internal deformation, and the friction shear stress  $\tau_R$  to the external friction. Both laws have a decisive bearing on die design. V. S. Ramachandran, K. P. Kacker and N. K. Patwardhan (India) proposed a method of identifying clay minerals in which the results of differential thermal analyses of dye-clay complexes is made use of for differentiating and identifying clay minerals. Thermograms of five types of clay minerals, viz. kaolinite, halloysite, illite, nontronite and montmorillonite, complexed with organic cations like malachite green, methylene blue, methyl violet and piperidine were presented. The dye-clay mineral complexes were shown to exhibit much more intense exothermic peaks than piperidine-clay mineral complexes. Kaolinite and halloysite dye complexes also exhibit exothermic dents of moderate intensities; of the four organic cations, methylene blue cations showed exothermic inflections of maximum intensity. M. E. C. Stedham (Great Britain) suggested a rapid method for determining the water absorption capacity of building bricks in less than 48 hr. The method consists in immersing the bricks in cold water for 24 hr, followed by evacuation in air, further immersion and final weighing. It has been found that immersion times (after evacuation) greater than 10 min. do not materially affect the results. It was concluded that under all circumstances the vacuum tank method offers a means of approaching saturation in the shortest possible time, and is suitable as a works control test. H. W. H. West and C. R. Atkinson (Great Britain) gave a brief review of the literature and their own work on the effect of the relative expansions and contractions of body and coating on the durability of roofing tile engobe. Thermal expansions, contractions on cooling and moisture expansion up to 20 hr in steam at 50 p.s.i.

were determined separately for engobe and body. The results show that under-fired engobe tiles might be expected to fail by 'shivering' early in service while those fired to 900°C. might be expected to fail by 'crazing'. Firing to 1000°C. produced a satisfactory engobe coating. Tiles fired to these temperatures and subjected to a natural weathering test confirmed this temperature dependence. A. Zwetsch (Germany) dealt with the measurements of expansion of kaolin and clay, parallel and perpendicular to the plane of the lamellae. The materials examined included kaolin, a clay containing kaolinite, a clay containing illite and a clay containing mica. No marked differences in expansion were observed up to 1000°C. with kaolin and clay containing kaolinite. The differences were greater with clay containing mica; the differences were particularly large with clay containing illite. The large expansion up to c. 600°C. which was regarded as a characteristic of the expansion-contraction curve of a clay containing illite was only to be found in samples in which the particles were parallel to the plane of the lamellae; it was not apparent in expansion-contraction curve of a sample in which particles were perpendicular to the plane of the lamellae.

### Pottery

A. Baudran (France), after reviewing the influence of moisture expansion on the body-glaze fit for earthenware, described the method of test used in the laboratories of the Société Française de Céramique. The assembly used permits measurement of expansions of the order of one micron. Ageing is carried out by treatment in an autoclave. Systematic tests made on four biscuit tiles of industrial earthenware subjected to steam pressures of 5-12.5 kg./sq. cm. and maintained for periods varying from 0.5 to 8 hr, have shown that even for high pressures applied for large periods, maximum expansion is not attained. This method was extended to new

bodies and the results were discussed on the basis of other properties like shrinkage, water adsorption, etc. The factors influencing the strength of high voltage insulators were discussed in a paper by W. Bauer *et al.* (Germany). An interesting paper on the role of industrial aesthetics was contributed by Ellies (France).

D. A. Holdridge and S. H. Ryder (Great Britain) reported the discovery of a new source of nepheline syenite in North Norway which yields a flux of great potential value to European ceramic industry. M. Inzigneri and G. Peco (Italy) presented literature survey on the influence of glaze under different stresses on the mechanical strength of vitrified ceramic bodies. J. de Jong (Holland) described the effect of certain crystalline additions and the crystalline products formed during firing, on the mechanical strength of porcelain and whiteware. The stresses in the glassy phase around the crystalline grains were determined from measurements of the coefficient of thermal expansion. This type of measurement can be used for effectively controlling the bond between crystalline grains and the glassy phase. R. Masson (Switzerland) stated that microstress has an unfavourable influence on the mechanical strength of porcelain body. This statement was corroborated by mathematical deductions of several workers. An experimental examination of this theory was accomplished with a series of bodies of varying composition, in which quartz was gradually substituted by two analogous materials with smaller thermal expansion coefficients. Bodies with less microstress proved to be mechanically stronger.

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