Meetings

Thermal Imaging Techniques

The principle of focusing the image of the sun or an incandescent source onto the surface of a solid body in order to heat the surface to a high temperature has been known since ancient times. However, it is only in recent years that serious consideration has been given to the utilization of this heating technique in industrial and domestic applications and in research in high temperature chemistry and physics. Interest in such techniques has been stimulated primarily by the increased technological importance of the high temperature chemistry and physics of chemical substances. Atomic warfare has also brought with it the desirability of simulating in the laboratory the high heat fluxes which are encountered in the proximity of nuclear explosions.

Consequently a conference to review and assess progress in the application of thermal imaging techniques was held on 4 and 5 October 1962 at Acorn Park, Cambridge, Massachusetts. While the majority of discussants were from the United States, other contributors came from Belgium, France, England, and Algeria.

Early investigations of the potentialities of thermal imaging techniques were devoted almost entirely to solar furnaces. Such furnaces have the advantage that the sun is a constant temperature heat source. However, they generally require relatively massive optical systems, varying from 5 to 100 feet in diameter; it is only possible to operate them when the sun is well above the horizon; and the output from the sun is attenuated by varying atmospheric and meteorological conditions. Faced with these inconveniences, suitable alternatives to the sun have been sought. Among the alternatives and the most popular at the present time is the blown, magnetically stirred carbon arc which has a temperature of about 6000°K. This arc attains the same sample temperatures or heat fluxes as those obtained with a solar furnace, and the apparatus is reduced to proportions which can be conveniently contained in the average laboratory. Because this apparatus is now commercially available and the basic characteristics of the devices are sufficiently well known, the conference members concentrated on their applications and not on the details of their design.

Arc imaging furnaces suffer from their own shortcomings; for many purposes the arc is not sufficiently stable and its anode is usually consumed in less than 20 minutes. Because of these deficiencies, new sources are of continuing interest. The utilization of three such sources was described in talks on high pressure, graphite-resistor lamps (D. L. Richardson, A. D. Little, Inc.), the carbon vapor lamp (G. P. Ploetz, Air Force Cambridge Research Laboratories), and high wattage xenon and mercury vapor arc lamps (W. E. Thouret, Duro-Test Corp.). Although lasers were not formally discussed at the conference, it was felt that progress in the development of continuously operating solid state devices should be followed closely.

Two experimental problems restrict the application of thermal imaging techniques more than any others. These problems are associated with the uniformity and density of the energy flux incident on the sample and with the difficulty of measuring the temperature of and the temperature distribution over the heated surface. The uniformity of the flux distribution is partly a function of the quality of the optical surfaces of the apparatus. Both a new method of fabricating large diameter parabolic mirrors inexpensively and a simple technique for testing them for geometrical perfection were reported upon (T. S. Lazlo, Avco Research and Development Division). Techniques for finding a focus at the plane of maximum area with constant irradiance were also described and practically demonstrated (C. P. Butler, U.S. Naval Radiological Defense Laboratory). Other authors described ingenious calorimeters and flux redistributors used in measuring or modifying the incident flux distribution.

Calculation of the temperature of samples from a knowledge of the incident or emitted energy is hampered by a lack of knowledge of the spectral angular emission and absorption characteristics of substances. Definite progress has been made, however, in the development of instruments which permit average sample temperatures to be estimated from measurements of the incident, emitted, and reflected energy. L. Eisner (Barnes Engineering Co.) described two spectroradiometers which show promise of yielding reasonable accurate temperatures in the 1000° to 2500°C temperature range in spite of a 25 percent uncertainty in sample emittance. A technique for determining spectral reflectance and emittance of a sample in an imaging furnace was also described (M. R. Null, National Carbon Co.).

About half of the conference was devoted to a discussion of research applications. Arc imaging furnaces had in every case been used, and a wide range of properties of substances are now being investigated. For research purposes the advantage of the image furnace technique is that it permits experiments to be carried out at temperatures in the 1000° to 3500°C temperature range under extremely pure conditions or in strongly oxidizing or reducing atmospheres. The sparsity of data on the chemistry of systems under these conditions makes it profitable to obtain even qualitative information only roughly related to the International Practical Temperature Scale.

Four papers given at the conference were devoted to crystal growth. The presentation by R. Poplawsky (General Motors Corp.) was particularly impressive because it suggested that single crystals of high melting substances can now be grown and zone purified with a high degree of refinement and control by using imaging techniques. The qualitative usefulness of imaging techniques was also illustrated by several speakers who presented the results of studies of the thermal degradation of organic substances, of reactions between inorganic solids and gases, of solid propellant ignition, and of the ablation of solids. Two presentations described plans for utilizing imaging techniques in high temperature mass spectrometry.

Melting point and emissivity measurements have been attempted with promise of success and apparatus is being developed for the measurement of electrical and thermal conductivities at high temperature. It was also demonstrated that, with skillful application, precise quantitative measurements can be made by using arc imaging techniques (H. Prophet, Dow Chemical Co.). Results of measurements of the heat capacity of boron nitride and aluminum oxide over the temperature range of 1300° to 2200°K were shown to agree well with measurements made by conventional techniques over the lower portion of the range.

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