lactose intolerance common in Chinese and Indians may have an acquired rather than a genetic basis. In addition, the incidence of this enzyme deficiency seems to be too high to be explained by a recurrent mutation.

This work has two implications. First, lactose intolerance should always be considered in Asian patients complaining of abdominal pain and diarrhoea. Second, it has a much wider socio-economic application when the part played by milk and milk products in food aid programmes to under-developed Asian countries is considered. It could be that aid in this form with the subsequent induction of diarrhoea is not the most efficient method of helping a malnourished community.

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APPLIED SCIENCE

Combustion of Coal in Oxygen

DURING an investigation of high temperature flames (at more than 2,500° K), we have developed a burner system capable of burning up to 6 g/sec (50 lb./h) of coal in oxygen to form a stable, continuous flame. An integral part of this development has been a study of the mechanisms which control the rate of combustion.

A detailed account of the burner system is given elsewhere¹ but, essentially, the coal was fed by a screw into a mixing device and then into the burner head. Flame stabilization was achieved within the burner head by means of a water-cooled bluff-body and combustion took place at atmospheric pressure in a zirconia tunnel.

Coal (4 per cent ash, 38 per cent volatile matter) was ground and graded according to size by sieving and centrifugal classification in air to produce seven fractions in an overall size range of 12–70 μ . Each fraction contained more than 50 per cent by weight within a 10 μ interval. Flame temperatures were measured by the line reversal method which indicated a variation in temperature along the length of the flame from 2,900° to 3,050° K. At this temperature we concluded that the reaction temperature remained sensibly constant along most of the flame length.

Each size fraction was burned at two ratios of oxygen to carbon: (a) with oxygen just less than stoichiometric for water and carbon dioxide production (assuming no dissociation), that is, a ratio of oxygen to carbon atoms of 2.11; and (b) at a ratio of 1.51. Burning times for the various fractions were compared on the basis of the distances from the burner head necessary for 80 per cent by weight of the coal to be burned. The extent of combustion was determined by means of a water-cooled sampling probe in which not less than 50 mg of solid material was collected during a flame immersion time of 30 sec. Burning times were calculated from these measured distances and calculated values of the particle velocities. Calculation of the velocities was based on the assumption that the particle velocity was the same as the gas velocity and the latter was obtained from measured values of the

Fig. 1. Effect of particle size on burning times. x, Oxygen-carbon ratio, 1.51; +, oxygen-carbon ratio, 2.11.

mass flow rate of combustion products, flame dimensions, flame temperatures and the computed composition of the products². The burning time versus particle diameter for both oxygen-carbon ratios is plotted in Fig. 1 and two conclusions have been drawn from these data.

First, over the particle size range of 12–70 μ , the burning times of coal particles in oxygen which give 80 per cent combustion can be described by the empirical equations

$$t = 2.8d + 16 \times 10^{-3} \text{ (oxygen-carbon ratio of 1.51)}$$

$$t = 2.4d + 9 \times 10^{-3} \text{ (oxygen-carbon ratio of 2.11)}$$

where t is the burning time in sec and d is the equivalent spherical particle diameter in cm.

Second, departures from the first approximation of a linear dependence of burning time on diameter have been explained in terms of the type of mechanism which exerts the predominant effect on the burning time. Between 12 and about 30 μ the data were satisfactorily correlated by means of linear relationships, whereas between 30 and 70 μ better correlation was obtained when it was assumed that the burning time was proportional to the square of the diameter. For single particles greater than 80 μ in diameter, it has been demonstrated³ that mass transfer processes control the rate of combustion. As the particle size is reduced, a critical size will be reached when chemical processes begin to play a significant part in determining combustion rates. On the basis that the time of burning is proportional to the square of the particle size when mass transfer processes predominate and proportional to particle size when chemical processes exert the greater influence on the rate of combustion, it is suggested that, in the conditions of these experiments, the critical size lies in the vicinity of 30 μ .

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