A QUALITY CONTROL SYSTEM FOR THE MANUFACTURE OF SPRAY DRIED MILK POWDERS

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To my wife, Jane

ABSTRACT

In the last decade the New Zealand dairy industry has greatly increased its spray drying capacity in response to the world market demand for spray dried milk products. Powder specifications are becoming increasingly complex and smaller quantities of each product are required as the number of different products grows. These factors have made it necessary to learn more about the way processing variables influence the product quality in order to improve product quality control.

A computer simulation model providing a complete description of the drier behaviour was developed from a series of experiments on a pilot scale spray drier. This took the form of regression equations relating the quality parameters of skim milk powder to the drier operating variables and the composition and physical properties of the skim milk. The model was then used in the development of a quality control system and also to simulate and evaluate a variety of commercial operating practices.

The characteristics of the spray drying process were investigated using the pilot plant evaporator and spray drier at the New Zealand Dairy Research Institute, which had been fully instrumented and interfaced to a process control computer. The drier studies confirmed the importance of low concentrate viscosity in the production of good quality milk powder. This could be achieved by keeping concentrate holding times to a minimum and by using high temperature, short time preheat treatments. The protein content of the skim milk was found to be the major determinant in the seasonal changes observed in concentrate viscosity, high protein contents giving high viscosities.

The study of the hydrodynamics of centrifugal pressure nozzle atomisers revealed that the nozzles used in milk powder drying fall into two distinct categories, each with characteristic behaviour in response to variations in fluid viscosity. The magnitude of the viscosity effect depends on the ratio of the swirl chamber and orifice diameters. The large capacity nozzles used in tall-form driers exhibit a marked decrease in pressure drop at constant flowrate as the viscosity of the concentrate fed to them is increased. This was found to play a very

important part in determining the overall behaviour of the drier. Five operating variables; the inlet air temperature and the concentrate total solids, feedrate, atomising pressure and temperature, proved to be necessary and sufficient to describe the drier performance and to predict the properties of the powder. Simulation studies of two outlet air temperature control strategies clearly demonstrated the superiority of inlet air temperature manipulation over that of concentrate feedrate, for driers employing large capacity nozzles.

The drier model was used in the selection, tuning and evaluation of a quality control system based on the SIMPLEX Evolutionary Operation scheme of Spendley et al. The process of spray drying milk powders presents several control problems. There are a number of quality parameters assessed by laboratory analysis, which means that feedback is multivariable, delayed and subject to error. Furthermore, the processing characteristics of milk change with time. A single measure of the powder quality was obtained from penalty functions based on economic considerations. After selection of the SIMPLEX step sizes with the help of the simulation model, a pilot plant trial of the scheme was conducted.

The Simplex evolutionary operation method was found to be a simple robust procedure which rapidly improved the product quality and maintained it in the face of disturbances typical of those likely to occur in commercial operation. The method provides two sets of plant conditions in advance, a feature which permits a substantial increase in the speed of attainment of optimum conditions for processes with setpoint response times similar to the time required to analyse the product quality. The Simplex method is therefore particularly suited to the manufacture of spray dried milk powders.

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