COMPUTER CONTROL OF THE MANUFACTURE OF SPRAY DRIED MILK POWDER

A thesis presented in fulfilment
of the requirements for the degree
of Doctor of Philosophy in
Industrial Management and
Engineering at Massey University

Owen Wong BE (HONS) (Electrical)
ME (Eng. Science)

July, 1979

To my parents, brothers and sister

in appreciation of their love,
understanding and encouragement

ABSTRACT

This thesis describes the development and application of modern control techniques to an industrial processing plant. The plant is made up of a pilot scale triple effect Wiegand falling film evaporator and a De Laval tall form spray drier situated at the laboratories of the New Zealand Dairy Research Institute.

The continuous version of the standard state space and measurement equations for linear, time-invariant, multi-variable systems provides the basis for the development. This standard representation is not well suited for direct application to the plant because of the difficulty in defining a suitable state vector and the need for a precise knowledge of the process dynamics. The standard representation is therefore enhanced to provide a modified structure that exhibits several significant features:-

i) only measurable outputs, control inputs and measurable disturbances are involved in the process descriptions;

ii) the equation structure is similar to that of the standard discrete state space equations, so that state space time domain control system design methods are applicable;

iii) the structure is suitable for the direct application of statistical modelling;

iv) maximum flexibility is offered for selection of discrete intervals for measurement samples and controls;

v) precise knowledge of process time delays is not required.

Application of the control strategies is performed using an IBM System/7 minicomputer. A suite of computer programs, developed in FORTRAN, is used. These programs are suitable for transferring to any other minicomputer supporting a multi-tasking mode of operation with the major system dependent area being the actual sampling of process data. Whilst a control engineer would be required for the installation of the software and initial control system design, further tuning of the controllers could be performed by a suitably trained operator.

The procedures described allow an operator to apply sophisticated control techniques by following a sequence of relatively simple steps:-

a) apply perturbations to normal plant operating conditions;
b) use the interactive graphics facility to identify process models using the generalised least squares technique;
c) choose appropriate design weightings and use a dynamic programming algorithm to obtain controller gains;

d) simulate operation of the controller using the process model;
e) apply the controller to the actual plant.

Steps b), and c) and d may need to be repeated until a suitable controller is obtained.

The results of the implementation of controllers on the pilot scale plant are presented. Consistent control of the product density and flowrate from the evaporator is obtained. As an hierarchical control structure has been used on the evaporator, the development of lower level controllers on variables such as steam flowrate, preheat temperature, inlet milk flowrate and condenser water temperature is also described. On the spray drier environmental control on concentrate flowrate, gas flowrate and drier chamber pressure is obtained.

ACKNOWLEDGEMENTS

The work described in this thesis was carried out as part of a joint project between the following organisations:-

Industrial Management and Engineering Department, Massey University;
New Zealand Dairy Research Institute;
Department of Scientific and Industrial Research;
New Zealand Dairy Board;
IBM (N.Z.) Limited.

I gratefully acknowledge these organisations for their provision of equipment and resources.

Within these organisations are individuals with whom I worked on a close, personal basis and to them I wish a very special thank-you.

Dr David Sandoz, Professor Kelvin Scott and Tim Hesketh of the IME Department for their continual support, enthusiasm and guidance of the work.

Chris Bloore and Tony Baucke of the NZDRI for the time and effort they spent with me in many invaluable technical discussions.

I wish to acknowledge also the Postgraduate Scholarship awarded by the University Grants Committee and Massey University.

Lastly, thanks to Coral Reid for the preparation of the final manuscript.

TABLE OF CONTENTS