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# **PROCESS DESIGN TESTING USING SIMULATION**

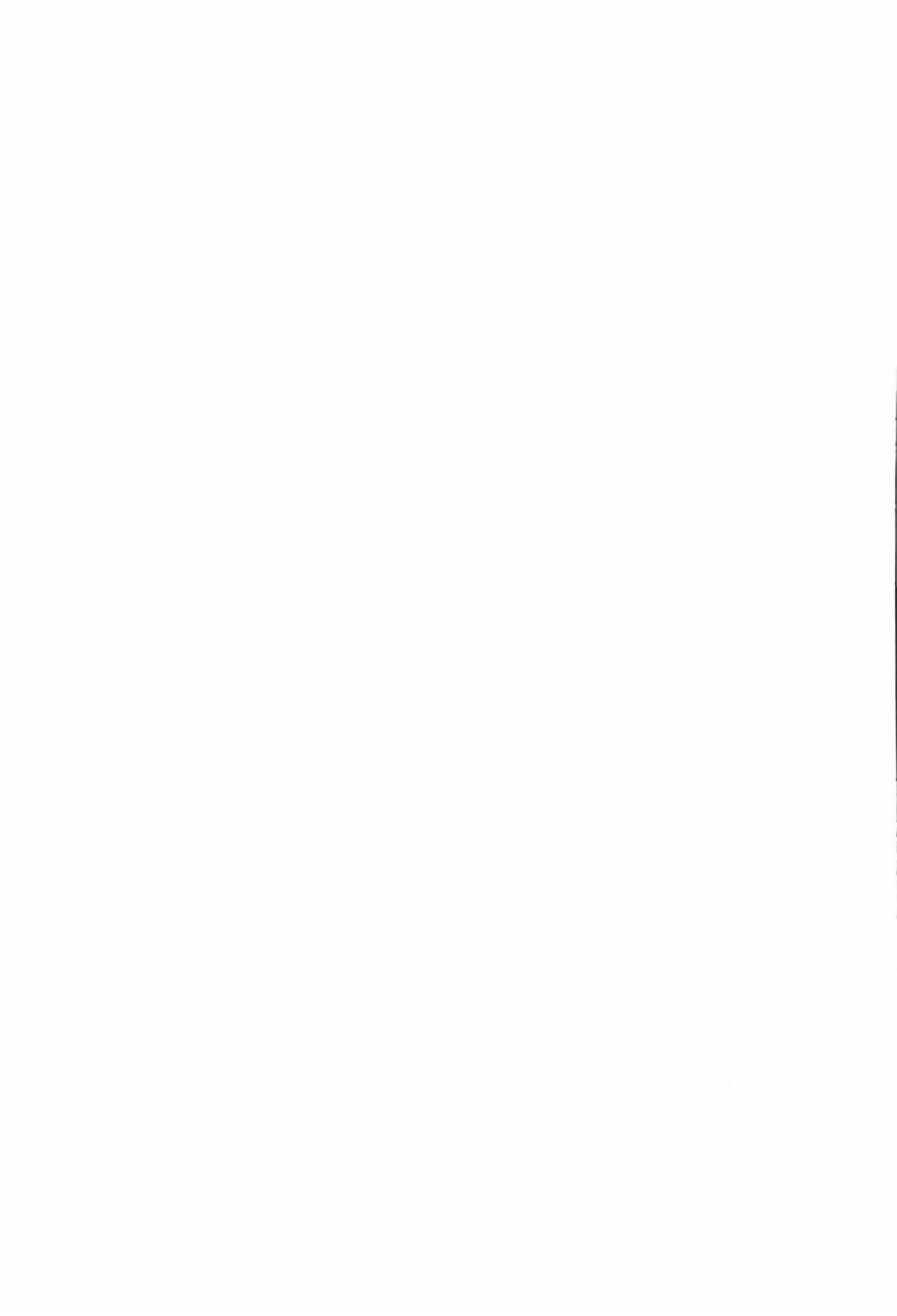
A thesis presented in partial fulfilment of the requirements  
for the degree of

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IN  
TECHNOLOGY**

At Massey University, Palmerston North, New Zealand.

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# SUMMARY

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Many industries are not getting full use out of their process equipment. Machine downtime due to breakdowns and unscheduled maintenance has been identified by SchemNZ Ltd as a major cause of under utilisation. The ability to schedule programmed maintenance before a breakdown occurs, rather than once something fails, and minimise the chance of breakdown through improved design will allow companies to operate more efficiently.

Improved methods of system design testing and a better knowledge of the types of faults and their causes will allow improved designs to be developed. Therefore, a scheme for design testing has been developed which includes components such as the identification of system and component reliability through data collection and simulation. A tool has been identified (Relex reliability software) that provides some component reliability information and facilities for system reliability modelling and simulation techniques such as Failure Mode Effect Analysis (FMEA).

A strapping machine and the 240-volt single-phase induction motor were chosen as case studies to identify the sorts of results that could be expected from modelling and simulation tools and to assess the feasibility of the design testing scheme.

The case studies resulted in the identification through modelling of a number of components in the strapping machine that have a high level of unreliability and could be the cause of many of the failures associated with the machine. In addition, the predominate failure modes for the induction motor were identified through FMEA models.

These results demonstrate that the design testing scheme can be used to predict the reliability of designs based on the past reliability of components. Furthermore, the most common or critical failure modes can be identified using FMEA allowing these failure modes to be targeted for prediction of prevention.



# CONTRIBUTION TO LITERATURE

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This chapter presents a summary of what this research contributed to its field of study and what specific documents were published apart from this thesis.

The contributions included:

- The conjecture of a structure for linking together tools such as existing software packages and databases with each other and with the ASK system.
- An introduction to the ASK system. Providing a unique way of linking engineers in the field with remote technical resources through the use of wireless audiovisual technology.
- A methodology was developed to allow existing simulation tools to be used to predict, prevent and identify specific types of mechanical failure in industrial systems. This was applicable both before systems were realised and after commissioning of the systems. The demonstration of how this research could be applied to practical situations.

The specific contributions to literature that were made as part of this research included a short correspondence, a paper presentation and a pair of posters. These are as follows:

- A short correspondence: Bakker, H. H. C., Schneider, W., Martin, N. K. L., (2003), Modelling for Predictive Maintenance and the Role of the Tele-expert. *J Chin. Inst. Chem. Engrs.* 34(6), 661-666.
- A paper presentation: Bakker, H. H. C., Schneider, W., Martin, N. K. L., (2002), Maintenance through the Tele-expert. In *A Symposium on Maintenance Engineering*, (pp. 15-24), New Plymouth, New Zealand: The Maintenance Engineering Society of New Zealand.
- A poster paper: Bakker, H. H. C., Schneider, W., Martin, N. K. L., (2002), Modelling for Predictive Maintenance and the Role of the Tele-expert. In *9th APPChE Congress and Chemeca 2002 (#572)*. Christchurch, New Zealand: The University of Canterbury
- An entry to the Foundation for Research Science & Technology (FRST) 2002 poster competition: Martin, N. K. L.: Design Testing Through Simulation.

In the case of the posters these publications demonstrated the research to a general audience while the paper and correspondence described the technical applications and implications of the research.



# PREFACE

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## **PROGRAMME OVERVIEW**

The research described here, 'Design Testing Using Simulation,' is part of the larger programme 'Remote Process Performance Monitoring and Process Design Auditing'. The goal of this is to provide SchemNZ Ltd with the expertise and technological capability to remotely (internationally) monitor and diagnose the performance of processing and manufacturing plants. This will permit the client companies to schedule maintenance of equipment rather than react to unexpected equipment failures. In addition, it will allow the client companies to retain trained staff locally rather than attempt to duplicate skills in each international market.

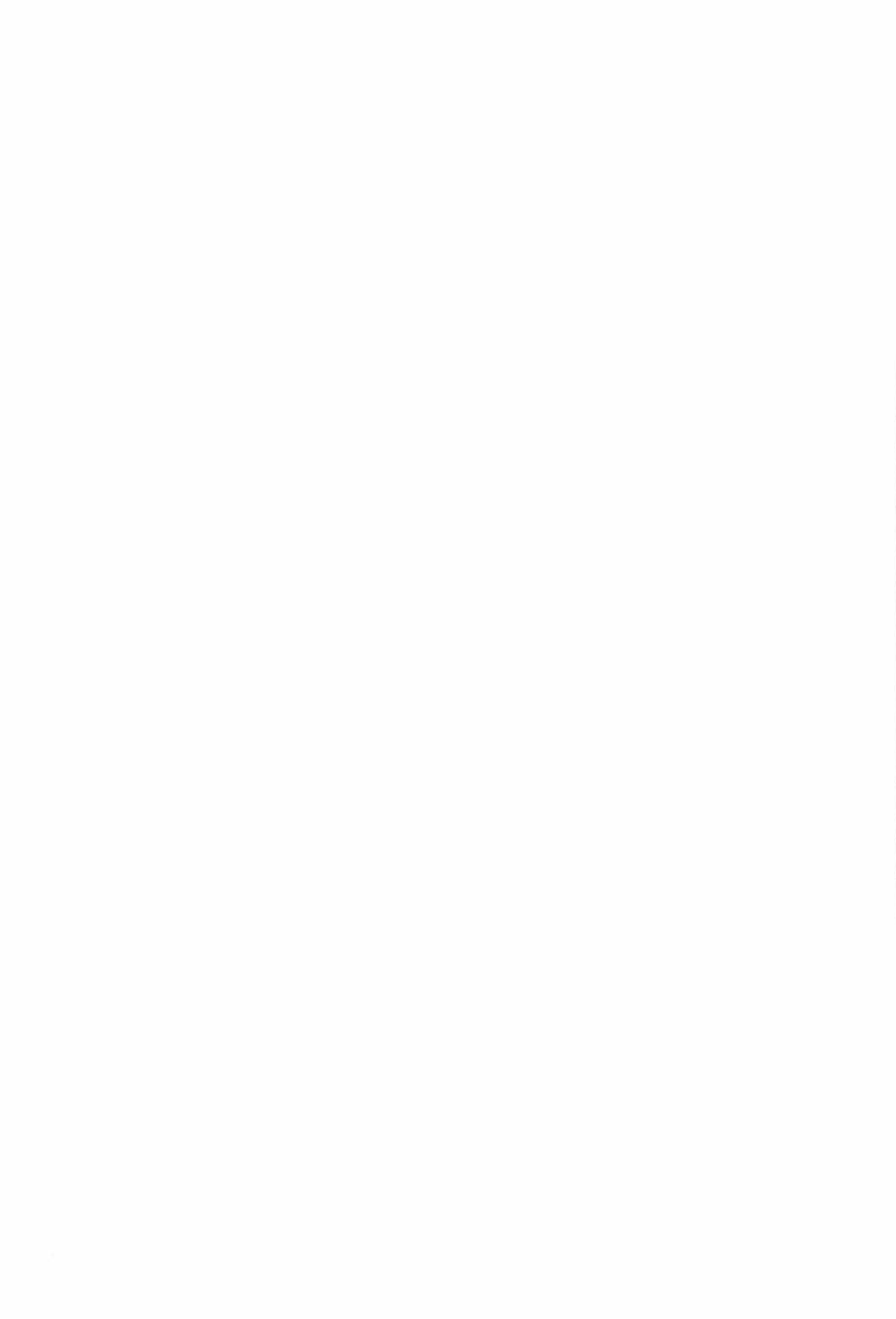
## **PROJECT DESCRIPTION**

Specifically this project investigates the use of process simulation software to audit process designs before construction and in particular, before overseas shipping. By trialing the software on a case study the company will gain confidence in the ability of the software to highlight problems with process designs.

Although the theoretical background for modelling and simulation has existed for some time, the application of these techniques is only becoming widely feasible with the advent of computers. Furthermore, the techniques are not yet as rigorous as those used in more traditional methods.

A large part of this project therefore is concerned with building techniques and systems that will enable further modelling to proceed in a high-quality fashion. The results of the simulation while important, are not the driving factor in this project. Rather the creation of a logical framework that can be applied to additional projects and the validation of the model's usefulness are the primary goals for this research.

This approach will lead to an integration of modelling techniques providing a system that allows useful simulations to be created quickly and easily.



# ACKNOWLEDGMENTS

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The author would like to thank: My supervisor Dr Huub Bakker for all his help and advice throughout my academic career. My mentor Werner Schneider for his support during my time with SchemNZ. The team at Graphpak for putting up with me and providing me with some much-needed experience. My family for their unfailing support over the years and most importantly of all, Natasha Nilsson my wonderful partner for being there.



A system is a big black box  
Of which we can't unlock the locks,  
And all we can find out about  
Is what comes in and what goes out  
Perceiving input-output pairs,  
Connected by parameters,  
Permits us, sometimes, to relate  
An input, output and a state.  
If this relation's good and stable  
Then to predict we may be able,  
But if this fails us – heaven forbid!  
We'll be compelled to force the lid!

Kenneth Boulding



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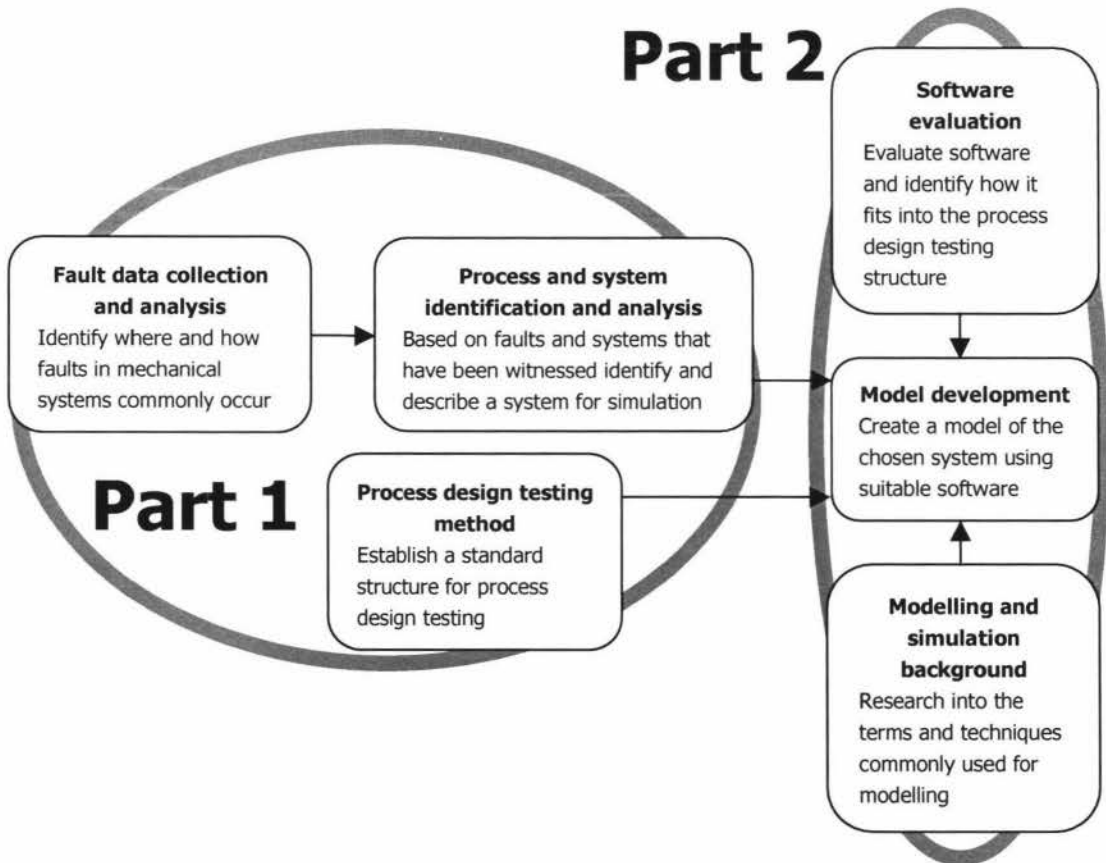
# INTRODUCTION

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The purpose of this research project 'Process Design Testing Using Simulation' is to look at ways to improve the efficiency of process systems through increased reliability, realised at the design stage.

The project was completed in partnership

with a number of companies, these were: SchemNZ Ltd (industrial technology consultants), Graphpak Services Ltd (engineers to the printing and packaging industry) and Relex Software Corporation (suppliers of Relex reliability software).



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**Figure 1:** Project structure



The goal of process design testing is to establish new or modified systems that have shortened design and construction cycles and are more reliable; auditing new system designs or proposed changes to existing systems before implementation is one method of achieving this. The auditing techniques developed here rely on modelling and simulation to provide predictions of various aspects of the system under consideration.

The background section describes the practical environment that has made this research necessary. Illustrated here are issues such as the economic importance of the work and the opportunities that exist because of the economic pressures. Some possible products are also suggested that could take advantage of these opportunities.

The practical aspect of this research is described in two major parts as illustrated in

figure 1. The first part of the project involves the identification of two processes for use as case studies, which will benefit from design testing and the development of a standard method for process design testing.

The second part of the project is concerned with the development of models for the case studies. This includes the evaluation of a large number of software packages and research into standard modelling techniques and best practices. This is followed by an evaluation of the case study results.

Finally, the conclusions chapter provides an overview of how this project has met its objectives and what knowledge can be drawn from the research. In addition, a section on future work provides direction for further investigation into this subject and describes the issues that are still unresolved or are in need of further investigation.