# METHODS TO IDENTIFY, QUANTIFY AND MINIMISE VARIATION OF NET WEIGHTS IN CANNED FOODS

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A thesis presented in fulfilment of the requirements for the

Degree of Master of Technology

FACULTY OF ENGINEERING AND TECHNOLOGY

MASSEY UNIVERSITY

NEW ZEALAND

2006

# Abstract

Using a $2^4$ factorial design model, the methods to identify and quantify the major sources of variation of net weights in canned foods were investigated. A piston filler was selected using modified starch solution as the filling medium. The stroke length and speed of the filler and the concentration and temperature of the filling medium comprised the four factors. The data were transformed into means and variances of fill weights from both across filling heads and across consecutive filling cycles, and were used as responses.

The responses, which were derived across filling cycles for each of the filling heads, were used as blocks, to evaluate the head effects. The projection designs were used to optimise variation and fill levels at set piston-stroke levels. The factor level combinations required to minimise variation and maximise fill level which was computed through a model matrix using all important effects were found to be P+,S+,T-,C+ and P+,S+,T+C+ respectively. The contributions of factors and their interactions to the short-term variance of fill weights were estimated using variance across heads within consecutive filling cycles (88.5%). The analysis across filling cycles within individual heads estimated the deviation of fix factor levels within the trials and contributed to 44%, which appeared as factor effects. Most of this variation (52.3%) which was caused by the unstable filling mechanisms appeared as the residual error. The analysis of blocks using heads was successful in partitioning the variance due to head differences (3.6%).The high volume operations generated a higher contribution from unstable filling mechanisms to the total variance, and a lesser contribution from head differences to the total range of fill weights. The recommendations include methods and materials to reduce the error in the design. Future research is recommended in the areas of vacuum and single shot fillers, multi-filling processes, and particle size variation.

# Dedication

I dedicate this thesis with love and appreciation to Piyadasa and Daisy Mary Vithange, my father and mother, and to Disinahami, my grandmother, for their inspiration, guidance and support in shaping my life.

# Acknowledgements

My supervisors, Dr John Bronlund and Dr Nigel Grigg, not only did an excellent job of supervising the research which was carried out at the Heinz Wattie site but also stepped out of their line of duties to rescue and put me back on the right track when the going was tough. I deeply appreciate their invaluable help in accomplishing this task.

Working towards a master's degree amidst the pressures of a demanding career has been a difficult task. I deeply appreciate the selfless and unconditional support of my dear wife, Ajantha Vithanage, in motivating me to complete this thesis and for shouldering most of my share of the household responsibilities during this difficult time.

I give sincere thanks to Anthony Bennet, the manager of project engineering, for recognising the importance of the role of DoE in the food-processing environment of Heinz Wattie Ltd, Hastings and for providing the much-needed funds for this research. Further, I express my appreciation and thanks to Trixie Ackerly for her expert advice in helping to shape up the desktop document numerous times, and to Graham Danes for his valuable comments during the revising of this document.

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# Glossary of Notations

| | |
|---|---|
| ANOM | Analysis of Means |
| ANOVA | Analysis of Variance |
| AQS | Average Quantity System |
| Brix | Percent of soluble solids on w/w basis on sugar scale |
| DIKT | Data-Information-Knowledge-Technology |
| DoE | Design of Experiments (Planned Experiments) |
| HACCP | Hazard and Critical Control Points |
| IQR | Inter Quartile Range |
| LQ | Lower quartile |
| LSL | Lower Specification Limits |
| LSM | Least Square Means |
| MFw-Ac-Fc | Mean Fill weights Across Filling cycles |
| MFw-Ac-Fh | Mean Fill weights Across Filler heads |
| NPPOSE | Normal Probability Plot of the Standardized Effects |
| PCA | The principal component analysis |
| PCOSE | Pareto Chart of the Standardized Effects |
| PCR | Process capability ratio |
| PLC | Programmable Logic Control |
| Pre-fill | Any filling components involved prior to final filling |
| SD | Standard Deviation |
| SKU | Stock Keeping Unit |
| SPC | Statistical Process Control |
| SSB | Sum of Squares Between Samples |
| SSW | Sum of Squares Within Samples |
| TQC | Total Quality Control |
| TQM | Total Quality Management |
| UQ | Upper quartile |
| USL | Upper Specification Limits |
| Var-Ac-Fc | Variance of Fill weights Across Filling cycles |
| Var-Ac-Fh | Variance of Fill weights Across Filling heads |

# 1 INTRODUCTION

**Chapter**

## 1-1 SCOPE OF RESEARCH

Heinz Wattie's Ltd. is a food company which manufactures about 1200 food products in the form of cans, pouches and frozen packs. In 1993, the author introduced Statistical Process Control (SPC), replacing the existing methods of control. The existing methods specified control of individual weights of cans within specification limits.

The initial stage of SPC (Statistical Process Control) involves the controlling of process averages within control limits. During the next stage, the variability of some processes was reduced by taking corrective actions for special causes. A total of over NZ$ 1.5m worth of "give-away" has been recovered. The proportion of time for which the process is in control has increased from 23% to 62% (Vithanage, 1994, 68). In spite of the initial success and ongoing improvements, the SPC programme was facing ever-increasing challenges from the following areas.

- Incapable production processes due to high variability of quantity and related quality parameters
- Control of weights while maintaining product safety and can integrity
- Control of weights while conserving product quality characteristics
- Expectations from overseas markets for tighter weight performance
- Increased consumer vigilance and meeting the regulatory requirements of different countries

A significant amount of direct and indirect saving will be made by meeting some of these challenges. For example, the cost of non-standard products due to under- and over-filling is around $ 500,000 per annum (Vithanage, 2003). The majority of quantity and quality related Nonstandard Products are due to the increased variations of output process variables. Although the total output variability could be reduced to some extent, a planned and systematic reduction was not possible for following reasons:

a) Lack of tools to identify and quantify the sources of this variability

b) Lack of knowledge of the optimum combination of the input variables, required to reduce the variation of net contents in canned products

Therefore, this study was aimed at developing methods to identify and quantify the contributing variations to the total variability of net weights. These process variables, which appear in the form of quality and other process parameters, would be identified and used as factors in the Design of Experiment.

Appendix 12 illustrates how the major sources, the factors within each of the major sources and the interactions among major sources, contribute to final and measurable net content variation in canned foods using the Japanese Beef Curry Process as an example.

## 1-2 PROJECT PROPOSALS

The overall goal of the project was to develop methods to minimise the variation of net weights in canned foods. The following two tasks were used to achieve this goal.

a) Identify and quantify the process variables, which contribute to net weight variability in canned foods using a liquid medium representing the key variables.

b) Develop methods to determine the optimum combination required of the contributing factors to minimise the variation of total net contents.

The optimum combination of the variables to reduce net weights variation, once quantified, provides a logical basis to optimise weights to reduce "give-away" and underweights.

These objectives were achieved by studying a representative medium through a selected filler. The information was then used to develop methodologies which are applicable to any product fill situation. The scoping of this study was therefore confined to the filler and product variability aspects represented in Appendix 12.

Project Stages

1) Process and Literature Reviews
2) Project approval from Heinz Wattie Ltd.
3) Screening of factors for planned experiment
4) Planned Experimentation
5) Data Collection
6) Analysis
7) Submission of Thesis