MINISTRY OF AGRICULTURE, FISHERIES AND FOOD

CSG 15

Research and Development

Final Project Report

(Not to be used for LINK projects)

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Project title	The optimisation of package formation and deformable product insertion
MAFF project code	**FT0601**
Contractor organisation and location	Department of Mechanical Engineering University of Bath Claverton Down BATH BA2 7AY
Total MAFF project costs	£ 50,652.00
Project start date	01/01/99
Project end date	31/12/99

Executive summary (maximum 2 sides A4)

Introduction

The objectives of this BRIDGE LINK project have been to provide the research group in the Mechanical Engineering Department, at the University of Bath with a broader view of the problems faced in the area of handling both products and packaging materials that are flexible and imprecise. The group's previous experience has been mainly in the creation and analysis of machine systems, in particular, those used in the packaging industry. Most of their research work has, and continues to be, in the application of constraint modelling techniques to the resolution of real design problems in this area.

Due to the nature of the industry it has been recognised that the group needs to expand its area of activity in order to understand the complex issues of the interaction of products, packaging and machine. If major advances are to be made in the industry by the creation of advanced machines, based upon new principles, it is necessary to gain a fundamental understanding of the principles involved in such complex interactions.

This one year study programme was thus obtained to allow some initial investigations to be undertaken into two specific areas, whilst additional funding and a student project has allowed research to be undertaken into the more generic issues of designing machines to apply these new principles.

Moving and forming
For major improvements to be made in the United Kingdom packaging industry, the fundamentals of product moving and forming need to be understood. Such an understanding will provide the basis upon which new efficient and adaptable machines can be created.

Flexible product
The initial, and major, investigation undertaken in this project was into the applicability of constraint modelling techniques to the design and analysis of machines handling flexible and irregular products.

Much research has been conducted into modelling such complex objects with advanced finite element techniques. These however mean that a large amount of data, on shape and distribution of material properties, is required to allow such models to be used reliably in a predictive mode. This is particularly difficult if many such actions are being undertaken sequentially as in a slicing and packaging operation.

The approach taken within the constraint modelling study was not to model the product in detail, but to investigate and bound the range of possible and acceptable motions that would result from such variations. The constraint techniques were then used to ensure that the machine would successfully handle that complete range without failing. This led to the concept of creating **product tolerant machines**, rather than that of many of the current activities towards highly intelligent machines (that need to be able to automatically adjusted to cope with any changes).

This investigation was undertaken through the study of the Thurne ham-slicing machine. The motion of the slice, away from the cutting wheel, was seen to be a complex set of relationships dependent upon wheel speed, slice thickness and resultant forward motion. The position of the table or mechanism catching the falling slices has to be reset to account for all such changes.

A high-speed video study was undertaken to allow a bounded envelope to be constructed to contain all falling products, irrespective of the machine parameters and product properties. The constraint modelling techniques were then employed to devise a catcher motion that followed the extremes of the fastest motion but also passed through the falling states of all slower. In this manner the lower speed and smaller samples could be caught in flight and made to follow the trajectory of the fastest, thereby making all slices follow the same final motion within an acceptable tolerance.

Various means were considered for achieving such a catching and motion-following device and the principles illustrated through the modelling of a four bar mechanism. Whilst this would be an additional device on an existing machine (which would lead to greater complexity) the principles of catching and motions-following based upon boundary analysis could readily be incorporated in the design of a new machine.

Packaging formation
In order to establish the optimum configuration for high speed forming of cartons an investigation was undertaken into the generic processes of folding. This identified the range of possible arrangements of surfaces and flaps, together with the complexity of the resulting folding operations.

Effort was directed in this study to not only establishing the commonly used forms but to also seeking configurations that would allow continuous motion and sequence of single linear foldings to take place. A number of alternatives have been developed and considered for implementing in new machine designs.

This study has identified limitations in information on the mechanical properties of packaging materials. This is to be addressed in a proposed project now submitted under IMI to the EPSRC working with a range of trade associations representing the materials and packaging industries.

Taxonomy for process and packaging machinery design

The two investigations in this project were finally brought together and considered in terms of the contribution they have made to the understanding of the broader issues of product, processes and machines. Here the relationships between the various activities in processing and packing were considered and the methods whereby they could be achieved were categorised. This led the research group to consider whether new processes and approaches could be created from first principles.

Two preliminary investigations have been undertaken. One was into the construction of a taxonomy for processing and packing. The other into the application of the “TRIZ” approach for determining, from the functional requirements, appropriate means whereby new or alternative designs can be generated. However the complexity of the processes and commercial decisions involved have led to the conclusions that the best role for constraint techniques is in modelling and decision making when redesign or modularisation is undertaken.

Conclusions

In this BRIDGE LINK study a number of elements leading to an understanding of the interaction of machines with products and packing were investigated and drawn together. These have led to a realisation of their significance within a generic process in which the functional requirements of the activities can be described and new processes and techniques sought to allow advanced new machines and processes to be created within the practical constraints of the industry,

This research will provide a basis of a major follow-on project building both upon this programme and upon AFM21, “A methodology for packaging machinery design”. As the industry faces major changes there is a need to create a systems methodogy that will allow effective changes in production processes and techniques to meet demands for greater flexibility. A practical method is to be investigated in a proposed project, based upon generic definitions, that will allow the various devices and machines from different suppliers to be integated through a common interface protocol. In establishing these procedures, analysis and modelling techniques created in this range of MAFF projects will provide the basis for determining the compatability of the systems and their overall performance.

Scientific report (maximum 20 sides A4)

Introduction

The major technical issues raised and resolved within this programme are presented in the three attached reports.

These issues are listed as follows:

1. High speed videoing allowed the range of trajectories of sliced ham to be determined from the slowest, thin to the thickest at highest speed. (Bath-01).

2. A motion profle could be determined to allow a catcher device to pick up the slowest and move them along the path of the fastest. (Bath-01).

3. A mechanical device was created to demonstrate the principle of a product independent catching device. This principle can be used upon other products, with differing devices.(Bath-01).

4. A preliminary study was made of packaging formation and the suitability of constraint modelling to handle it. (Bath-02).

5. This study identified a lack of information about the mechanical properties of packaging material; these are needed in order to create reliable models. (Bath-02).

6. A brief study was made of a taxonomy for processing and packaging.(Bath-03).

7. This established the complexity of the subject and identified the appropriate role for constraint modelling within the structure. (Bath-03). Here a systems approach is proposed, the the analysis and conformation aspects being handled as constraint based models.

Attached project reports:

Bath-01
Bath-02
Bath-03

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