AN AUTOMATED SYSTEM FOR THE SLAUGHTER AND DRESSING OF BOVINES

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Summary

The CSIRO Division of Food Processing, Meat Research Laboratory (CSIRO), and the Meat Research Corporation (MRC) have carried out a program of research and development into aspects of abattoir automation. The slaughter and dressing operations necessary for processing bovines have been studied, and a full scale research prototype slaughter and dressing system has been commissioned. This has demonstrated that the following processes can be successfully automated for bovines in the weight range of 280 - 800 kg liveweight at processing rates of up to ninety carcasses per hour.

i)	Conveying of live animals to slaughter chamber;	ii)	Restraint of animal for slaughter;
iii)	Rendering the animal insensitive to pain;	iv)	Exsanguination;
v)	Removal of horns;	vi)	Removal of the hooves;
vii)	Hide removal (in part);	viii)	Sternum separation;
ix)	Separation of pubic symphysis;	x)	Separation of head from body;
xi)	Viscera removal and tail severance;	xii)	Separation of the carcass into sides.

The first commercial application of the system, known as FUTUTECH, is currently under construction and is now being installed in a commercial abattoir in Australia. This, the <u>commercial</u> prototype, will undergo trialling and commissioning early in 1993.

Introduction

The traditional practices of slaughter and dressing of bovines are labour intensive. Process workers are required to carry out tasks which are repetitive, monotonous, unpleasant and, in some instance, dangerous. Automation has the potential to provide a better working environment for the employees, increased efficiency of operation and reduced unit cost of product. However, little advance has occurred in the development of automated bovine slaughter and dressing systems in the last three decades. As a result, CSIRO and MRC have collaborated in a research and development program to provide the meat processing industry with a substantially automated slaughter and dressing system which would improve the working environment and efficiency of processing bovines.

Materials and Methods

A study of conventional abattoirs was carried out to identify the individual tasks involved in slaughter and dressing. A quantitive description was then given to each task and the task input and output states defined. Production data from conventional abattoirs, such as weight, breed and production rate, were analysed to specify the operating range required for the system.

A sequence of automated actions was determined for each task. The sequence was required to produce, from a given input value an output value equivalent to that obtained by manual operation. Pre-prototype mechanisms were then designed, constructed and trialled to evaluate the various actions and sequences.

Based on the outcomes of pre-prototype trialing, a full scale research prototype, known as FUTUTECH, was constructed and trialled at an abattoir adjacent to the research laboratory. This slaughter and dressing system processed bovines for export. It was subject to the same directives and requirements promulgated by various regulatory authorities for the operation of conventional abattoirs. Experimental data was obtained on both individual modules and the operation of the complete system. The results of the analysis of this data were used to modify the system for commercial use.

Results and Discussion

The research prototype, FUTUTECH, demonstrated that automated machines could perform many of the tasks presently being carried out manually. In particular, the more arduous tasks and those involving the greatest risk of personal injury could be automated. Individual modules could be interconnected to form a system which could process all breeds of bovines in the live weight range of 280 - 800 kg at processing rates of up to ninety animals per hour, and thus meet the overall specification.

The large variation in bovine size and weight precludes the use of conventional robotics. Bovine anatomy is difficult to describe mathematically and the operations involve relatively large payloads. Mechanical replication of the actions of a process worker performing a manual task is also precluded, as human control system of the process worker cannot be replicated in a cost effective manner at present.

The FUTUTECH system is described below.

Lead up, Restraint and Stunning Module

The first module provides the means to separate one animal from a group of bovines being lead up the race prior to slaughter. This is achieved by a moving floor conveyor combined with a set of pressure sensitive roller gates which follow the contour of the animal and close behind the animal. An overhead pusher locates the rear of the animal and automatically feeds the animal into the stunning chamber. The floor of the stun chamber is lowered and the animal is supported by two longitudinal bars under the leg pits. The neck is captured between two vertical bails. With the animal fully restrained, an electrical potential is applied to the brain via the neck bails to stun the animal. A further electrical potential is applied to the animal from the neck bails to the longitudinal bars which stops the heart.

Exsanguination Module

Exsanguination is carried out automatically in the following sequence. The neck capture bails are adjusted to fully stretch the neck of the animal. A pneumatically powered knife penetrates the hide and enters the thoracic cavity above the sternum. The aorta is then severed. Bleeding occurs through the neck wound.

Horn and Hoof Removal Module

The carcass, still in the prone position, is conveyed from the Exsanguination Module to the Horn and Hoof Removal Module which automatically removes the horns and hooves. Sensors locate the horns and hydraulic cutters then sever the horns at the base of the skull. Similarly, sensors locate the base of the hooves and hydraulic cutters sever the hooves from the legs.

Bed Dressing Module

The carcass is conveyed from the Horn and Hoof Removal Module to the Bed Dressing Module. The carcass is automatically rolled from the prone to supine position and located in a cradle. The cradle is attached to a slat conveyor which permits the process workers to move with the carcass. The tasks of sealing the oesophagus, severing the diaphragm and preparing the hide for subsequent automatic removal are carried out manually. Both forelegs and rear legs of the carcass are shackled in preparation for transfer to an overhead conveyor.

Overhead Conveying

After the carcass has travelled to the end of the Bed Dressing Conveyor, it is lifted by pneumatic scissor action to an Overhead Conveyor. Unlike traditional abattoir practice, the carcass is suspended horizontally by all four legs (i.e. hooves up) on a dual rail conveying system. It is transverse to the direction of travel of the conveyor. The first section on the conveyor provides a park station to allow the manual task of rectum separation and sealing to be carried out.

Pubic Symphysis Module

The carcass is conveyed to the Pubic Symphysis Module. Sensors locate the pubic symphysis and it is automatically divided using a small circular saw at the end of an extendable arm.

Hide Removal Module

The carcass is conveyed from the Pubic Symphysis Module to the Hide Removal Module. Sensors locate the portion of hide which has been manually peeled from the carcass at the bed dressing module. Four clamps automatically grip the hide, pulling it away from the body and then over the head.

Head Removal Module

The carcass is conveyed from the Hide Removal Module to the Head Removal Module where the head is automatically separated from the body. A sensor determines the position of the first cervical vertebra. The head is clamped and a hydraulically powered cutting blade severs the head. The head clamp is articulated and this module transfers the severed head to a hook on the head chain.

Sternum Module

The carcass is conveyed from the Head Removal Module to the Sternum Module. A sensor locates the xiphoid cartilage. The sternum and xiphoid cartilage are then automatically divided using a hydraulically powered cutting blade mounted at the extremity of a hydraulically powered extendable arm.

Evisceration Module

The carcass is conveyed from the Sternum Module to the Evisceration Module where the viscera is automatically removed from the carcass. A hydraulically powered extendable arm enters the thoracic cavity, a sensor located at the end of the arm locates the spine, and the arm follows down the spine pushing the viscera out between the rear legs onto the viscera table. The tail is automatically severed from the carcass at this module. A sensor located at the end of an extendable arm locates the tail and a hydraulically powered cutter attached to the arm severs the tail.

Splitting Saw Module

The carcass is conveyed from the Evisceration Module to the Splitting Saw Module where it is automatically split into two sides using a bandsaw. Sensors locate the spine and control the movement of the platform to which the saw is attached such that the saw cuts along the mid-sagittal plane. The sides are then conveyed to manual trim and weighing stations.

Control System

The complete operation is computer controlled using PLC's at each module for local control and a master PLC for system control. A typical module control sequence is the division of the sternum and xiphoid cartilage. A cutting blade is located at the end of a hydraulically powered extendable arm with photo optic sensors located adjacent to the cutting blade. The signal obtained from these sensors input to the controlling computer which outputs instructions to the extendable arm and cutting tool. This permits the sternum and xiphoid cartilage to be divided in accordance with a dedicated algorithm programmed into the computer.

Conclusions

Many of the manual tasks now performed in slaughter and dressing of bovines have been automated. Automated systems and sub-systems can be designed to operate in commercial abattoirs. The first of these automated systems will be operating in a commercial abattoir in Australia early in 1993.