MEAT TECHNOLOGY UPDATE
Cutting edge technology for the meat processing industry

Meat technology update

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Towards automated boning – a case study: sheep boning equipment

The development of boning machines for the Australian sheep processing industry was funded to a significant extent by the Australian meat industry. This has involved the industry and a New Zealand equipment developer working together from concept through to commercialisation.

Automation of, or mechanical assistance with, boning tasks promises big advantages in terms of process efficiency and employee health and safety. This Update uses the development of sheep boning equipment as a case study to consider the various issues involved in such development.

The driver – a changing process environment

Australia processes between 25 and 35 million sheep and lambs per annum—split approximately 50:50 between lamb and mutton. As much as 50–60% of mutton is processed into boneless product, whereas less than 10% of lamb is processed into boneless cuts.

The focus on development of mutton boning equipment during the 1980s and 1990s was due to:

- the low value of mutton and the production-driven status of the mutton processing sector at that time;
- development in Australia of specialist mutton hot-boning operations during the late 1980s and 1990s with high speed production chains and extended operation; and
- less concern about product appearance of boneless mutton compared to lamb cuts.

Boning developments were therefore primarily aimed at boning mutton, with application to lamb where appropriate. In order to be successful it was identified that the machines developed must:

- be robust and cost effective;
- process the entire range of product presented—carcase weights 15–40 kg, condition from emaciated to over-fat;
- minimise downgrading due to tissue damage;
- operate successfully on chilled and pre-rigor cuts;
- consistently achieve high yields over a wide range of product sizes; and
- minimise the inclusion of bone particles in product.

Objectives and overview of development

Clear objectives were set by the Meat Research Corporation (MRC) for sheep processing technology development during its Sheepline 2000 Key Program. The overall objective set was—by 1996—to develop, modify and introduce technology and methods to provide a new processing environment conducive to improved technical skill, co-operation and efficiency in the industry. The goal was an initial productivity improvement in sheep processing of 20% by 1996 across the total industry; and further sustainable improvement of 2% per year over 10 years from 1996 onwards.

The development of the machines was expected to achieve reductions in labour requirements, and demonstrate to industry how processing costs can be reduced by one third. There would be a reduction in the necessary skill levels and elimination of tasks with a high potential for injury to workers. Yield would be improved and boneless product of consistent quality would be produced.

The machines were expected to accept a wide range of product size and condition and, with minimal preparation:

- enhance process and product versatility;
- be safe and simple to operate;
- be robust, hygienic and functional in design and construction;
- be easy to clean; and
- be modular—each machine standing alone yet complementary in a system.

Development of equipment commenced in the late 1980s and progressed in three distinct phases.

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Prior to Sheepline 2000

From about 1988, MRC funded development of shoulder and trunk deboning equipment. The machinery concepts were primarily developed through direct communication between MRC and the New Zealand engineering company MACPRO, with limited other input.

Sheepline 2000 (1993 – 1996)

MACPRO was retained to develop shoulder, trunk and leg deboning machinery under the MRC Sheepline 2000 Key Program. The program was subject to considerable management, analysis and review with respect to milestone achievement, industry assessments and a technology action group.

Post Sheepline 2000

During this phase, development continued under the Partnership and Plant Initiated Programs where costs are shared with specific Australian meat processing plants. Project assessment and management was reduced, as a large part of the development risk was carried by MACPRO. The eventual purchasers of the machinery had more input into design during this stage.

Equipment developed

Leg and trunk boning machines have been commercialised under projects funded primarily by the Australian industry.

Leg deboner

A leg deboning device was successfully commercialised from a project that ran for a period of 2–3 years. Prior knowledge from an ovine deboning program which commenced at MIRINZ in New Zealand during the 1980s was fundamental to the quick realisation of the leg deboning technology.

Figure 1: *abt*-3ML leg boning unit

The *abt*-3ML leg boning machine depicted in Figure 1, was developed primarily for the mutton boning industry, to bone either chilled or pre-rigor legs. The product comes off the machine as a tunnel-boned leg with the patella still in the meat. Tissue damage is minor and yields are comparable to, or better than, manual boning processes.

The leg deboner is a compact stand-alone unit requiring air and electrical services. It is loaded from the front with automatic ejection of product and bones. Loading is currently performed manually, but a mechanical loading device is being developed.

Boning is performed by the scraping and cutting action of two chucks, which simultaneously separate the meat and bone from both ends until the chucks meet in the middle. The bone is then ejected through the hollow lower chuck.

Both chilled and pre-rigor product can be processed in the same machine, although optimum performance is achieved by tuning for product in either one condition or the other.

Performance

Once loaded, it is 4–5 seconds before the next loading cycle can begin. Production rates in excess of 9 legs per minute are currently being achieved. The machine will process a wide size-range of product, with yield being the only major impediment to processing product having very small bones.

Yield

Yield improvement over manual boning ranges up to 5%. The actual yield benefit realised will depend on the control and management of the manual boning team.

Productivity

The machine is able to comfortably produce 420 boned legs per man-hour (210 carcases per hour). In a manual boning system production is approximately 240 boned legs per man-hour. A conservative estimate of productivity benefit from implementation of a leg boning machine is 0.11 man-minutes per leg.

Investment payback

Estimates for MLA of payback period at various production levels and yield improvements indicate that at a product level of 500,000 carcases per annum with a yield improvement of 3% or better, the payback periods are better than 24 months. The return on investment (ROI) would exceed 40%.

Trunk deboner

The single station *abt*-5MT trunk boning machine shown in Figure 2 is a derivative of the *abt*-4MT four station trunk boning machine. It was developed primarily for the mutton boning industry for processing chilled or pre-rigor trunks, clearing backstraps from the spine and fleecing the ribcage. The product is produced as soft trunk sides, from which the backstraps can be pulled. The remainder can be passed on for trimming and shoulder bone removal.

After loading, the trunk is conveyed backwards, away from the operator, under the backstrap blades. These blades clear the meat from the vertebrae about 50mm either side of the centre-line. At the end of the stroke the trunk is in position for the fleecing operation to take place. The fleecing blades are introduced either side of the vertebral dorsal projections in the area just cleared, and sweep around the ribs to

Figure 2: *abt*-5MT trunk boning unit

remove the meat. A second set of knives simultaneously clears tissue from the base of the neck. The trunk support is then returned to the loading position. The frame is dropped to a tray as the next trunk is being loaded. The product and skeletal frame are ejected to the left side of the machine, to be conveyed or lifted to tables for further work. Complete removal of the meat from the brisket and neck is dependent on carcass condition and pre-work.

Both chilled and pre-rigor product can be processed in the same machine; and the machine can be fitted with an option that includes saws that remove the breast and flap.

Performance

Production rate

Once loaded, the cycle time is approximately 12 seconds before the next loading cycle can begin. During this time the operator will do some of the preparation work or follow-up processing.

Yield

Yield improvement over manual boning ranges up to 5%. The actual yield benefit realised will depend on the control and management of the manual boning team.

Productivity

For the full fleecing operation the machine, with one person in attendance, can process 210 trunks per hour. With the brisket saw option in place, the process speed can increase to 300 trunks per hour because the time required to fleece the ribs is reduced. With on-rail manual boning, production is approximately 60 carcases per man-hour; and, with on-table boning, approximately 30 carcases per man-hour.

Investment payback

MLA estimates of payback period at various production levels and yield improvements indicate that at a production level of 500,000 carcases per annum and a yield improvement of 2% or better, the payback period would be better than 24 months. In these circumstances ROIs would exceed 40%.

Indirect benefits of boning equipment

Labour demand

Labour availability has become a major issue for regionally based industries, such as sheep and lamb processing operations. Ignoring the cost benefits of the boning machinery, it is possible that such devices could be installed to effectively reduce labour requirements.

Product consistency and appearance

While product from the deboning machines is unlikely to be as good in appearance as that produced by a highly skilled boner (sharp knife separation is superior to ploughing, scraping and compression), with good operation and maintenance practices, the products from the machines will be consistent.

Within a boning team there will be a range of skills, and there is likely to be a significant turnover of team personnel resulting in variability in the resultant product.

A machine operator requires significantly less training than a highly skilled boner to produce a consistent product.

Occupational health and safety

The boning machines significantly reduce the number of people who may incur injury from either knife cuts or repetitive strain. The physical effort required by the operator for loading and discharge can be minimised by careful attention to integration of the machines.

Hygiene

While evidence is difficult to accumulate for individual installations, it is generally recognised that less manual handling improves the hygiene status of the final product. Utilisation of the boning machines is likely to improve final product hygiene due to reduction in handling by a boning team.

Success of the program

The number of mutton and lamb carcases processed into boneless product fell over the five-year period 1999-2004 from around 11 million to less than 8 million per annum. The number of lambs processed has remained relatively constant but mutton numbers have fallen significantly.

During this period there was also a significant increase in the value of mutton livestock, rising from \$10–\$20 per head in 1999–2000 to \$30–\$50 in the 2001–2005 period. Low raw material prices encourage the development of production-driven priorities which were characteristic of the mutton processing sector during the 1990s. This in turn encouraged the development of automation and created a processing environment with potential for yield improvement.

In the period from early 2001, the reduced numbers of mutton available and the increased livestock value have encouraged processors to:

- adopt a more flexible approach and include more lamb in the processing mix of plants that had previously concentrated on mutton processing;
- reconsider production-driven strategies and improve value-adding due to the increased value of the raw material. There is some evidence that boning production speeds have reduced in order for the boning teams to improve yields and product quality;
- diversify to a wider range of markets that require different mixes of bone-in and boneless product.

Mutton livestock values are not likely to change significantly in coming years due to low sheep stock numbers, diversity of market demand and strength of the live export sector.

Equipment sales

Investment in the development of mechanised sheep boning equipment by MRC commenced in 1989 but the first sale in Australia did not eventuate until almost 10 years later. There have been 13 units sold, with the last sale in Australia in 2002 (Figure 3).

Success in meeting objectives

When assessed against the objectives of the *Sheepline 2000* program, it is clear that some of the objectives were unrealistic with an overly ambitious timeframe and limited funding; however, the developments have contributed to improved technical skill and efficiency in the mutton sector. Machine installations have resulted in an approximate 10% improvement at plant level and about 1% for the total sheep processing industry. While the overall industry benefit falls well short of the target of reducing costs by one third, the benefit to the individual enterprise is significant and worthwhile.

The projects were successful in producing a commercial return for the industry, for the adopting enterprise and through the collection of royalties.

Lessons learnt

By looking back and reviewing projects, lessons can be learnt that can be applied to similar future projects.

- Industry drivers need to be reviewed to ensure projects continue to address relevant issues. The changing environment can lead to more conservative returns than initially projected. The rise in price for mutton and consequent changes in boning practices demonstrate this.
- Innovation is best achieved through industry defining the broad problems and innovators working closely with individual enterprises. Despite the industry assessments and input of the technical advisory group, this was inadequate during the first stages of this program.
- Successful innovators need to be supported and early adopters need to obtain some advantage and may need assistance. Capital discounting and a lead time of at least 12 months over competitors have been successful.
- It is difficult to accurately estimate the time and cost of commercialisation as, in this case, the first machine was installed in 1997; the goal was to have achieved a 20% improvement by 1996.

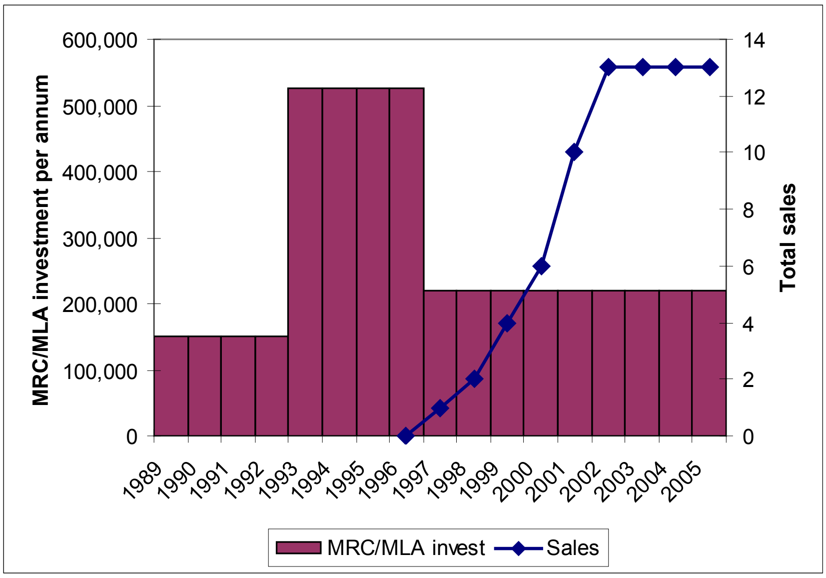

Figure 3: R&D investment and equipment sales

Further reading

Meat & Livestock Australia (2005) Measuring and communicating the value of MLA programs. Project Report PIAP.023D.

Contact us for additional information

Meat Industry Services is supported by the Australian Meat Processor Corporation (AMPC) and Meat & Livestock Australia (MLA).

Brisbane:
Food Science Australia
PO Box 3312
Tingalpa DC QLD 4173

Ian Eustace
T +61 7 3214 2117
F +61 7 3214 2103
M 0414 336 724
Ian.Eustace@csiro.au

Neil McPhail
T +61 7 3214 2119
F +61 7 3214 2103
M 0414 336 907
Neil.McPhail@csiro.au

Alison Small
T +61 7 3214 2109
F +61 7 3214 2103
M 0409 819 998
Ali.Small@csiro.au

Sydney:
Bill Spooncer
PO Box 181
KURMOND NSW 2757
T +61 2 4567 7952
F +61 2 4567 8952
M 0414 648 387
Bill.Spooncer@bigpond.au

Adelaide:
Chris Sentance
PO Box 178
FLAGSTAFF HILL SA 5159
T +61 8 8370 7466
F +61 8 8370 7566
M 0419 944 022
Chriss@ozemail.com.au