Snapshot report

AMPC
AUSTRALIAN MEAT PROCESSOR CORPORATION

Implementing exoskeletons in meat processing

The implementation of cobotics and exoskeletal devices for the Australia red meat processing industry – Phase 1

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Final Report Snapshot

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1.1 Introduction & context

Exoskeletons are human assistance devices that are worn by a person, adjusted for optimal fit and activated to provide posture, movement and force assistance for the targeted parts of a person's body. Mechanical structures and components operate to move and support the targeted part or parts of the wearer's body inherent to the intended design features of the worn device. Exoskeletons currently exist for a wide range of body locations that include the neck, trunk (lower back), shoulders, thumb and fingers and lower limbs (hips and knees). There are even shoe technologies that deliver energy back to a person during movement.

This assistance provided by an exoskeleton can be as simple as holding one or more joints in a fixed position, like a splint, when they experience force exertion against an object (Ottobock Thumb X). They can also be as complex as a worn soft garment, such as a glove, that can accentuate the grip and holding forces of the thumb and fingers, based on the settings of the pressure sensors within the device, and the application of AI that enables the device to learn, adapt, anticipate and then activate grip movement patterns and the levels of force applied to perform manual tasks (Bioservo, Ironhand bionic glove).

The recent and abrupt emergence of Artificial Intelligence (AI) as a disruptive technology that may revolutionize industry practices and efficiency, reflects many years of investment, development, testing and refinement.

There appears to be a similar pathway with the development of current and emerging human assistive devices, such as exoskeletons. These devices, with their origins in the use of mechanical splints and aids (orthotics) to assist humans to overcome disability and limited physical function are undergoing a rapid transformation in the type, capacity and application of assistive mechanisms that are being specifically designed to enhance human capability beyond normal or average levels. Like AI, these technologies may have the capacity to revolutionise how manual work is performed, particularly for industries where there are substantial challenges in mechanising and automating manual processes due to task complexity and specific environmental and compliance requirements. Conditions that prevail within the Australian red meat processing industry.

The emerging availability of exoskeletons and other human assistance technologies, such as cobotics and collaborative robots, has substantial implications for the red meat processing industry that has, and continues to, rely on the sophisticated hand-eye co-ordination and proprioceptive* capabilities of humans, which are normal human attributes.

*(*proprioception = sense of knowing where the hands are within a space without having to look at them to control their movement)*

1.2 Project objectives

To investigate the range and type of exoskeletons devices that may be of use to the Australian red meat processing industry and then establish a platform for the industry to be able to critically evaluate and, where appropriate, implement these devices, the AMPC commissioned this project.

The core objective of this project was to evaluate current and emerging exoskeletal devices for the Australian red meat processing industry to:

1. Ascertain where the solution can be deployed now within the industry.

2. Ascertain where the solution can be deployed now, with minor changes.
3. Ascertain where the solution could be evolved for future deployment.
4. Understand the benefits (if any) that exoskeletal devices can provide to meat processors across a number of tasks in both sheep and beef processing.

1.3 Approach

This project was conducted in 3 distinct stages:

1. Stage 1 – Identification and selection of current and emerging devices.
2. Stage 2 – Laboratory based testing of selected devices.
3. Stage 3 – Site (processor) based testing of selected devices.

Stage 1 of the project began with an initial literature review. Because of the rapid advances in exoskeleton technologies over the past decade orientated toward their use within industry, a lack of high calibre and informative peer review literature was revealed. Of the limited number of papers discovered, they either significantly pre-dated newer technologies or they could not demonstrate sufficient confidence in their ability to anticipate and extrapolate the results into the complex industrial, environmental and regulatory setting of the meat industry. Accordingly, the limited literature review conducted didn't deliver any substantive contribution. Much of the information obtained for reference within this project was grey literature that described, evaluated and promoted devices, without necessarily having a solid evidentiary basis of their medium and long term impact once implemented.

While the literature was being undertaken, a parallel search for current and emerging exoskeleton technologies was conducted. This involved gathering the devices that had already been promoted and provided to the meat industry for review as well as conducting internet searches that eventually focused on review web sites and the sites of device developers and manufacturers.

At the outset of this project, there were no devices manufactured within Australia and only one device had an existing distributor within the country. All devices were sourced from overseas manufacturers and/or distributor. While a number of well-established devices for the back and shoulders were provided by manufacturers based in the United States of America, the newer and emerging devices of most potential relevance to the meat processing industry were located within Japan and Europe.

An open mind on the design and features of devices was maintained to facilitate the potential to discover innovations that may be suitable for, or be adapted to, the meat processing industry. Nineteen devices were selected that covered the back, upper limbs and lower limbs. Other devices, in particular, active or powered devices for the back and shoulders, were located. However, it was either not possible to establish contact with the manufacturer or they could not be convinced to provide their devices into Australia, ahead of any plans to market their product and establish a distribution and support network here.

As the procured devices arrived, the Stage 2 laboratory testing activities were conducted. This largely involved familiarization and practice with each device and its method of adjustment for optimal fit and determining how the assistive features of each device worked. For some devices, measurements of muscle function with and without the device being worn were conducted. These tests were conducted to confirm the broad claims of what the device does to assist the wearer. This information was indicative and useful but did not constitute a formal study of their function.

During this stage, a range of functional, operational and safety criteria considered to be fundamental for use of an exoskeleton with the meat processing industry were established. The criteria were intended to guide the assessment of potential devices and enable those exoskeletons least likely to be useful, or those that may be the most difficult or complex to incorporate into the complex meat processing environment, to be quickly filtered out and excluded. The ability to clean a device after use was identified as a fundamental industry requirement in exoskeleton design. A device with innovative features may not be usable in this environment if it cannot be adequately cleaned after use. These criteria were developed at each stage of the project and have been consolidated into a 5-step guideline for the evaluation and implementation of exoskeletons for the red meat processing industry (see Appendix 9.1).

Stage 3 of this project commenced with the selection of those devices found to be most suitable to the broad needs of the meat industry. The full list of devices is described below. Those devices selected for in-processor trials have been bolded.

Trunk - Back

1. Hal-LB01, by Cyberdyne
2. Japet (corset), by Japet
3. **Apex, by Herowear**
4. **Bionic Back, by hTRIUS**
5. **Hapo Back, by Ergosante**
6. Back X, by Suit X/Ottobock
7. **Laevo Flex, by Laevo**
8. Laevo 2.57, by Laevo
9. Paxeo Back, by Ottobock

Trunk - Neck

10. Paxeo Neck, by Ottobock

Upper limbs – Shoulders

11. **Hapo Front (was MS), by Ergosante**
12. Evo Vest, by Ekso Bionics
13. **Paxeo Shoulder, by Ottobock**
14. Exo-01, by Hilti (rebranded Ottobock Paxeo Shoulder)
15. Shoulder X, by Suit X/Ottobock

Upper limbs – Hands and Fingers

16. **Ironhand, by Bioservo**
17. **Paxeo Thumb, by Ottobock**

Lower limbs – Hips and Knees

18. Leg X, by Suit X/Ottobock
19. Chairless chair, by Noonee

Of the eight shortlisted devices, the Bioservo Ironhand glove was identified as the device most likely to have the greatest impact across the broadest range and number of meat processing jobs when compared to the other devices. This powered glove reduces grip forces to grasp and manipulate tools, objects and parts of a carcase being processed. Because of the high level of likely application within meat processing, the Ironhand glove was prioritised for processor-based testing.

Different methods of protecting the selected devices were developed, as much as possible using conventional personal protective clothing (PPC) likely to be available within a processor. Plastic smocks were procured to protect back and shoulder exoskeletons during testing if local PPC items were found to not provide sufficient cover.

Four meat processors were approached to participate in testing. Two sheep processing facilities and two beef plants. Testing was conducted at the two beef plants only. One was in country Victoria and the other in Queensland. These tests focused on the use and evaluation of the Ironhand glove within production (slaughter) and processing (boning and slicing) areas. The design and function of the other selected devices were presented and discussed during these site visits.

1.4 Project outcomes & insights to benefit AMPC members & the industry

This primary outcome of this project was the identification of devices that are suited for short to medium term use within meat processing facilities in Australia. It is not possible to predict likely long-term use of any device within this industry as there are too many unknown factors. These devices most suited to short to medium term use include the powered glove, several trunk and shoulder devices, and thumb splints (see Section 1.3 above). The devices not recommended for implementation were found to be effective and functional as exoskeletons and the main reasons for their exclusion at this time is the complexity of cleaning them after daily use.

The project delivered an additional range of diverse outcomes that went beyond the selection of exoskeletons for implementation. These additional outcomes include the identification of a broader range of strategies that might steer the industry to get best use of assistive devices for jobs that require this assistance as well as increasing the use of data gathering within exoskeletons so they can establish a pathway to better inform how increased mechanisation and eventual automation, or semi-automation of industry jobs may occur.

The following outcomes were achieved within this project:

1. Literature review.
2. A simple categorization method for exoskeletons to understand their core attributes relative to the meat processing environment.
3. Selection and procurement of 19 exoskeletons for evaluation.
4. Exoskeleton evaluation outcomes.
5. Development of a step-by-step process to guide meat processors in the evaluation and implementation of exoskeletons and other human assistance technologies such as cobotic devices and collaborative robots.
6. Development of a state of knowledge regarding the rapidly emerging exoskeleton industry, innovative devices being developed and the opportunities that exist for the Australian red meat processing industry.
7. Identification of the benefits of defining the nature of meat processing jobs and tasks to drive the development of exoskeletons and other human assistance technologies.

1.5 Conclusions & recommendations for further research/actions

The primary conclusion of this project is the confirmation that exoskeletons and other human assistance technologies have great potential to be useful in not only reducing the physical demands of many manual tasks performed within the industry and possibly improve the physical efficiency of operators, but how they may be used to better understand the nature of production and processing tasks and accelerate the development of greater mechanisation and automation across the industry. This active engagement of the industry with these technologies is compelling.

However, the functions of these technologies need to be balanced with the ability to incorporate these devices into the day-to-day requirements of the industry for meat safety, wearer safety, operator and product hygiene, maintenance of product quality and production efficiency. A range of devices assessed within this project have been recommended for prompt implementation.

Secondarily, the co-ordination of the exploration of and engagement with these technologies could be maximised by the development and resourcing of a specialist group within the industry. This group could be part of an AMPC initiative and could steer the direction of greater engagement with relevant and useful technologies, which could include working with developers of these technologies to better accommodate meat processing industry requirements.

In summary, the key recommendation of this project is to convene a specialist industry reference group to focus on human assistance technologies to create the framework to co-ordinate and oversea the next steps in the greater engagement with current and emerging technologies for the Australian red meat processing industry. The group could be formed under the AMPC research and development umbrella and be established as an industry project.

The recommended main functions and approaches of this reference group are:

1. Convene the reference group within an AMPC project to represent industry stakeholders. Establish the objectives, operational parameters and budget for this group.
2. Establish a road map to define the pathway for the acceleration of the initial implementation of exoskeletons found to be of likely use for the industry within this project as well as the broader exploration, development and uptake of other human assistance technologies that will provide optimal benefit for the industry. The short-term goals of this initiative should be to enhance the work capability of employees within meat processors, while the long-term goals should be to influence greater mechanisation and process automation by utilising advanced technologies and learning from any data generated and the experience of their application and use.
3. Develop a standardized job assessment format that defines the physical work tasks performed within the industry . This reference should describe the summary features of the postures, movements, forces exerted and duration and frequency of meat production, processing and ancillary jobs. This will provide a foundational reference for the consideration and matching of human assistance technologies and is likely to support the early identification of opportunities for enhanced mechanisation and automation.
4. Develop global relationships with technology developers and form active relationships with those that have devices most pertinent to the meat processing industry. These relationships should be based on communicating the needs of the industry with these technologies and working with them to achieve designs that work within this environment.
5. Develop a media platform for this industry reference group to communicate its activities, messages and outcomes as a means of supporting the education of the industry about human assistance technologies for the industry.
6. Adopt the 5-step guideline developed within this project to standardize and support the short-term implementation of exoskeletons. This guideline outlines methods to evaluate prospective exoskeletons and support the implementation of devices found to have the greatest potential to assist the industry.
7. Implement the exoskeletons found to be suitable for prompt use across the industry. Use Step-5 of the guidelines to steer this process.