SNAPSHOT

PROJECT TITLE
Feasibility research and evaluation of miniaturised snake robotics for spinal cord removal prior to splitting beef carcasses

Project Report Reference: 2017-1085   **Date:** 9 Sept 2017

Project Description

Since the beginnings of the BSE crisis, BMC, UK has been involved in the consideration and indeed evaluation of methods for spinal cord removal in beef and lamb. A main conclusion is that the removal of spinal cord is best done when the carcass is whole, which requires an "intelligent" tool to drive up the cavity, following the spine, extracting and scraping cord and nerve tissues, leaving the inside of the spinal cavity free of any "risk material". After head removal and evisceration, spinal cord removal in beef carcasses may be done when the carcass is whole (unsplit) using miniaturised Snake-arm robot, as an "intelligent" tool to drive up the cavity, following the spine, extracting and scraping cord from the inside of the spine. The Path taken by the Snake-arm also defines the spine geometric profile, facilitating accurate splitting by automation.

OC Robotics and BMC have been the providers in this project, delivering the target Snake-arm model as functioning 1-meter long unit, with 13.5 mm cross section for the first time.

Project Content

Beef carcasses are split with spinal cord in the carcass, causing spread of cord tissue. This project has quantified the anatomical variability in beef carcass spine features relevant to the specification and construction of a Snake-arm robot for navigation a tool for beef spinal cord removal. Snake-arms are commonly used in the nuclear and chemical sectors. They are generally several meters long with a cross-section diameter of 250 mm. The miniaturisation process, which is the main content of this project has had a target for a 1-meter long, 13,5 mm cross section robot arm capable of travelling up the spinal cavity of a whole beef carcass entering through the neck hole after head removal and evisceration, but before splitting. Such a robot arm would also provide data that could be used for more centered splitting along the vertical line of the spinal using automation.

The need for accurate splitting by automation and removal of spinal cord is clear in the current beef slaughtering operations. Using a knife blade to reduced width of the cut, compared to a 3.5 mm saw blade, also provides yield saving. The estimated saving from increased efficiency and yield may reach A$ 360,000 per year.

Project Outcome

As a first pioneering step, this project has reached the practical implementation of a fully operational 13.5 mm cross section, 1-meter long Snake-arm, bringing the possibilities of an automated beef spinal cord removal solution closer to reality. The Snake-arm has been tested in an engineering environment, showing its capability to manoeuvre a 90-degree bend having a 100mm radius of curvature.

The operation of a Snake-arm robot needs to accommodate carcass variability and this research has quantified the following as relevant to its design:

- Carcass weights range: 120Kg to 400Kg in general,
- Carcass length, from hook attachment point to the tip of the neck: 2,000 mm to 3500 mm.
- Length of the spinal cavity as measured along the cavity: 1500 mm to 2800 mm,
- Spinal cavity cross section (best fit smallest circle): 14 mm to 25 mm (30 mm at neck entry)

| No	mm
1	21
2	26
3	19
4	23
5	27
6	24
7	21
8	20
9	19
10	21
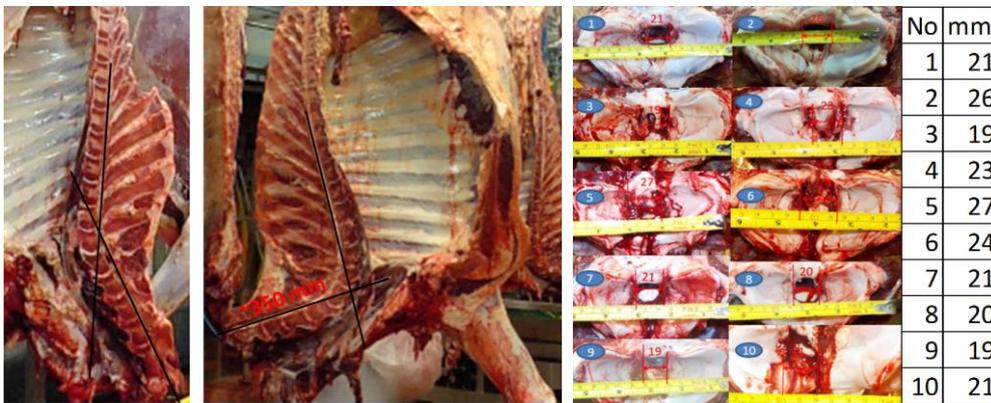
- Angle of change in the spinal cavity: 15 degrees to 90 degrees at worst on a 100-mm radius.

The variability of the diameter along the length of the cavity poses the main constraint on the cross-section diameter of the Snake-arm being considered in a miniature form. A suitable design overcoming this constraint has been achieved.

The change of curvature in the spinal cavity in the neck region poses another constraint on the construction of the Snake-arm, with challenge for it to travel along the channel after a sharp bend. This has also been considered and resolved.

The project has reached successful construction feasibility of a miniaturised Snake-arm robot with live presentations of trials in an engineering environment.
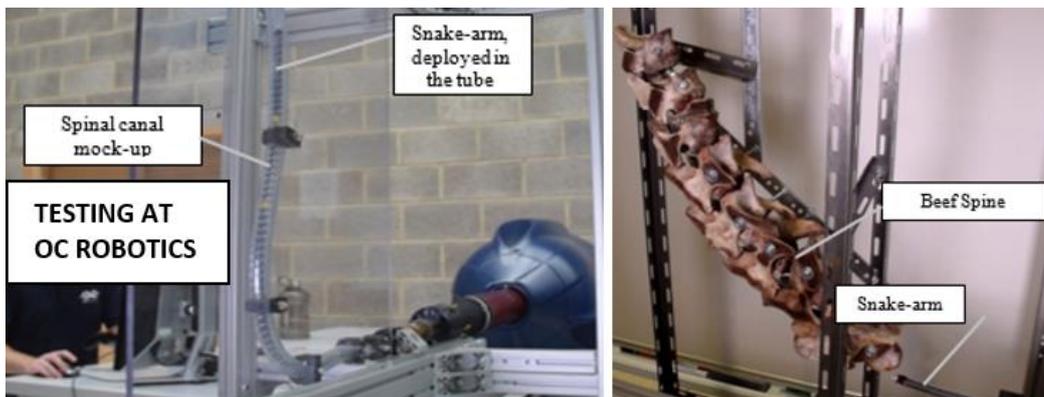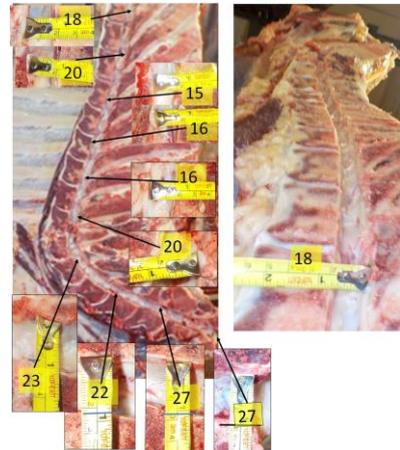
Benefit for Industry

It is the longer-term intent that the cord would be removed by such a robot arm, whilst providing data that could be used for a more accurate splitting, following the centreline of the spine, along the length of a whole beef carcass. This has benefits as follows:

- Improved yield avoiding soft siding by having accurate spine profile data for the calculation of line of cut for splitting,
- Increased containment of spinal cord as it would be removed prior to splitting, which is currently performed by a saw blade spreading the spinal cord tissue,
- Improved efficiency, as cord removal is a manual process as is splitting in most plants.

Two units of labour are generally used for splitting and two for cord removal at 60 carcasses per hour. In some plants, additional labour is used to clean the spinal channel after splitting, and prior to the cutting room. The target of two operator savings at A$ 140,000 is anticipated as a minimum in the cases of both cord removal and splitting.

Soft-siding and inaccuracies resulting from splitting misalignment results in rework and loss of yield in around 1 or 2 carcasses per hundred. Saw blade thickness of 3.5 mm, generating bone dust during splitting resulting in an estimated loss of A$ 80,000 per year at 60 carcasses per hour in a single shift operation. The overall value proposition of the combined splitting and spinal cord solution is estimated at A$ 360,000 per year. Additional benefits include improved quality and shelf life (relating to bone dust), reduced spread of high risk spinal cord tissue, otherwise requiring intensive wash as well as subsequent reduction in water use.

USEFUL RESOURCES

http://www.ocrobotics.com/