



final report

Project code: P.PSH.0341
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Date submitted: January 2009

PUBLISHED BY
Meat & Livestock Australia Limited
Locked Bag 991
NORTH SYDNEY NSW 2059

Data Capture (Smart Stimulation)

This is an MLA Donor Company funded project.

Meat & Livestock Australia and the MLA Donor Company acknowledge the matching funds provided by the Australian Government to support the research and development detailed in this publication.

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Executive summary

The purpose of this study is to report to MLA & Australian beef processors on data capture & validation trials for Smart Stimulation.

Remote access to the Smart Stimulation controller and data capture / transfer has been developed in conjunction with two plants: one in NZ (Riverland Eltham) and one in Australia (ACC Brisbane).

The mechanism to permit remote access to the SS controllers has been defined and described in previous milestones. In partial completion of Milestone 3, the following steps have been completed:

1. Remote access of the Smart Stimulation controller at Riverland Eltham. This system is being used as part of the ongoing calibration of ultimate pH prediction; this involves regular contributions to a database that combines the Smart Stimulation responses with carcass data, including ultimate pH. This process has validated the remote access/data capture mechanism, and is also being used to validate a procedure to continuously monitor and upgrade the performance of the Smart Stimulation system based on a joint contribution from the plant and CT.
2. Modification of Smart Stimulation software to permit interface with plant database at Silver Fern Farm, Pareora. Pareora has instituted a skid-ID system that is used to collate all the data associated with each carcass. To integrate the Smart Stimulation quality predictions with the database, the Smart Stimulation software was modified to permit communication with the plant IT system. This allowed the transfer of the carcass data to the database in real time. This system has now been instituted and validated.
3. The mechanism to institute a remote access with the Smart Stimulation controller at ACC has been defined with the ACC IT department. This process is essentially complete but has not been made operational at this time. This is due to a last modification to the stimulation electrodes, identified during the last calibration work in November, that prevented the Smart Stimulation system from being fully commissioned (a modification to the stimulation electrode, carried out to prevent difficulties with stimulation of vealers, caused a fault in the electrical isolation of the first electrode).

Commissioning is expected to be completed by the end of February and the procedures for remote access and data capture will be validated in the ensuing period.

Refer to Appendix 1 for a detailed report on Information Systems for an Electronic Smart Stimulation System. See attached.

Contents

	Page
Error! Bookmark not defined.	
Executive summary	2
Background	4
Project Outline.....	5
Project Objectives	5
Results, Discussion & Outcomes	5
Acknowledgements	5

Background

Smart Stimulation provides a unique combination of automated processing control and quality measurement, and the commercialisation and assessment of the commercial benefits of this technology are underway. Smart Stimulation will be able to measure every carcass processed and identify those carcasses not meeting MSA's pH / temperature window required for optimal meat quality.

It is expected that Smart Stimulation will provide substantial financial benefits to processors by increasing the number of carcasses meeting the MSA grade, as well as providing significant labour and cost savings for QA testing on a day to day basis and for MSA assessments.

The responses of the carcass are measured using load cells, and the signal is analysed using a PC. The PC then controls the electrical stimulation unit by either stopping the stimulation or modulating the electrical waveform delivered to the carcass. The system has been installed into 4 plants so far, and 2 more are planned for the coming year. The work so far has identified a number of opportunities to upgrade the recent system to give it greater flexibility and functionality.

1. Differences between processing plants means that some modifications to the electrical control systems are needed. There is now enough experience with different plants to define a generalised framework for the electrical system that would break the system down into modules that could be applied universally. An immediate requirement is to upgrade the system to manage a 22 carcass/minute system.
2. At present, the control for the SS is not integrated into any existing plant IT systems. There are a number of predictions about carcass attributes that need to be signalled to the plant control system, and a generalised interface to undertake this task needs to be developed.
3. Critical to instituting the SS system is the calibration system. This means ensuring that carcass numbers and their responses on the load cell are effectively linked, even in circumstances when the control system is not immediately adjacent to the stimulation system.
4. Upgrading the system to allow remote access to the control system to allow performance monitoring and data collection.

Project Outline

The scope of work:

Milestone and achievement criteria
Progress report on each component of the project
Develop data capture system & conduct preliminary pilot trials with processor(s) partners. Report to MLA & processor(s) including ACC on remote data capture & linkage between carcass number and load-cell responses
Validation and on-going data capture Report to MLA & processor(s) including ACC on data capture & validation trials for Smart Stimulation

Project Objectives

The objectives of this project proposal are to assist with the refinement of the data handling systems that underpin the Smart Stimulation Technology, specifically this will include:

1. Upgrade of existing electronics platform to allow installation into a high throughput plant;
2. Develop an interface to allow integration of information from the Smart Stimulation system onto the grading ticket;
3. Linkage of carcass number to the load-cell response to allow for automated calibration.

Results, Discussion & Outcomes

Refer to Appendix 1 - Information Systems for an Electronic Smart Stimulation System

Acknowledgements

Meat & Livestock Australia acknowledges the matching funds provided by the Australian Government to support the research and development detailed in this publication. MLA partnered with Meat and Wool New Zealand and wishes to acknowledge their contribution to the project.

Embedded in computer modelling and shared between M&WNZ and MLA.

IP is shared between MLA and M&WNZ, on the condition that MIRINZ Inc will be acknowledged in any media release or public statement concerning the results of the MLA / M&WNZ collaborative research programme.

ENGG200-07C

**Information Systems for a
Electronic Smart Stimulation System**

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Table of Contents

1	Introduction	1
2	Organisation	3
2.1	Staff	3
2.1.1	Other Staff	4
2.2	Activities	4
3	Background	5
3.1	Meat Electronics	6
3.2	Animal Individuality	6
3.2.1	Variables	6
3.3	Controlling Glycogen	7
3.4	Glycogen, Lactic Acid and pH	8
3.4.1	pH	8
3.5	Why is pH important?	9
3.6	Meat Quality	10
3.7	Electronic Stimulation	11
3.7.1	Traditional Electrical Stimulation Techniques	11
3.7.2	Dealing with the Individuality — ‘SmartStim’	12
4	Work Placement	15
4.1	Acclimatization	16
4.2	Smart Stimulation System Controller	16
4.2.1	Choosing the controller	17
4.3	Wireless, Virtual Computer Network System	19
4.4	Remote Access	20
4.4.1	Pilot Installation	22
4.5	Data Storage	23
4.5.1	Smart Stimulation Software	24
4.5.2	Database	24

4.6	New System	25
4.6.1	Temperature Experiment	26
4.7	Meat Quality Model – Web Interface	27
5	Conculsion	31
	Glossary	33
	Bibliography	37

List of Figures

2.1	Organisation Chart	4
3.1	Glycolysis Reaction Rate λ variance due to Ambient Temperature T	8
3.2	pH Temperature decline window	9
3.3	The impact of carcass Chilling rate on pH	10
3.4	The effect of Electrical Stimulation on pH	11
3.5	Smart Stimulation System	12
4.1	Initial plan for the first few weeks of the summer work placement	16
4.2	National Instruments CompactRIO PAC	18
4.3	An Industrial Computer	18
4.4	Hardware for Virtual Network Computing	20
4.5	General connectivity diagram between Smart Stimulation System and Carne Technologies	21
4.6	TIA/EIA-568-B cable connection of a Category 5e cable into an RJ45 connector	22
4.7	The Fedora logo	23
4.8	Example FTP connection and transfer of files	24
4.9	Smart Stimulation Data organised in a Database format	25
4.10	Control Cabinet wiring	26
4.11	Temperature experiment raw data from logger	27
4.12	Interface Design Flowchart	28
4.13	Meat Quality Model – Enter data	28
4.14	Meat Quality Model – Results screen	29

List of Tables

3.1	Benefits of Direct Electronic Inputs to Processor (Simmons et al., 2007)	6
3.2	Common pH values, with comparisons to Meat. (Meat & Livestock Australia, 2003)	9

Chapter 1

Introduction

This report is an account of the experiences that I have enjoyed during my Summer Work Placement in 2008.

Work placements are an integral part of the Bachelor of Electronic Engineering program, designed to give opportunities to apply knowledge gained on-campus but also to practise skills which are not taught at university.

The place of employment was Carne Technologies Ltd, in a project involving the development of electronic stimulation apparatus for the red meat industry. This report will talk about the company, deliver a background to the project, describe the work completed and discuss the results.

:

Chapter 2

Organisation

Carne Technologies is a relatively new company to the meat industry. Carne Technologies is based in Cambridge New Zealand, which is 22km from Hamilton. This is an ideal location in central waikato which is the farming hub of New Zealand.

The powerhouse behind Carne Technologies is Clyde Daly and Nicola Simmons. Clyde and Nicola are meat scientists, who are driving the leading edge of research in this field.

Clyde and Nicola are former employees from the MIRINZ (Meat Industry Research Institute of New Zealand) centre, which is now part of AgResearch who is the main agricultural research institute in the Waikato region.

Carne Technologies are a small → medium business who employ approximately ten people. The business is relatively new, being in existence since incorporation on 31st of July 2003.

The primary objective for the company is to carry out Research and Development in the area of Meat Science. This means that they are primarily working for:

- Meat and Wool New Zealand
- Meat and Livestock Australia
- Local and International Meat Companies (Processors)
- Local and Intrenational Farmers (Producers)
- Consumers

Also with their research and development, they carry out validations of meat quality. This may also sometimes part of the research.

Carne Technologies has a fully functional laboratory, which is capable of doing many types of experiments in relation to meat quality.

2.1 Staff

Clyde Daly is my immediate work supervisor. His position in the firm is the Research Director. I report daily to Clyde and he gives me the tasks to complete.

There was also lots of opportunity to work with Clyde on electronics problems. Clyde has a passion for applying his theorems to real life applications, and in this field of meat science electronics play an important role.

It was interesting to work with Clyde as he is able to display a deep understanding into many areas, and where he comes across new technology or ideas is willing to learn and embrace these with enthusiasm.

Nicola Simmons is the manager of Carne Technologies. Nicola is the person to contact for any issues which are not immediately associated with the project. Nicola organises the timing for the current and future jobs, to ensure that there is a good work flow for the lab.

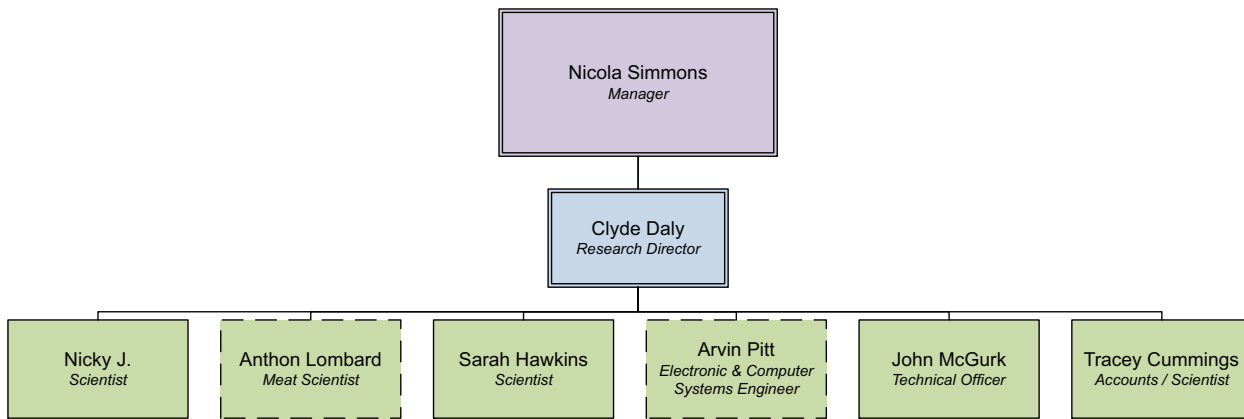


Figure 2.1: Organisation Chart

Sarah Hawkins, Nicky J., John McGurk and Tracey Cummings make up the usual staff at Carne Technologies.

2.1.1 Other Staff

Anthon Lombard and myself are temporary staff at Carne Technologies. I am doing a work placement on developing information systems for the electronic smart stimulation system and Anthon is doing a masters on meat quality matters.

2.2 Activities

:

Chapter 3

Background

Electronics are an integral part of society. There are a large number of electronic devices used world-wide, from the personal computer, mobile telephones to specialised circuits which are performing actions for people and yet more electronic devices. They are also becoming increasingly used to improve industries. The Red Meat Industry is no exception. (Meat & Livestock Australia, 2005).

The use of electronics in the Meat Industry is now widespread, being used on the farm, in the processing plant and right through to the retailer. The integration of electronics into this industry has many advantages, but it has particular importance with regard to supply chain management and quality control.

There are *two* main types of uses for electronics in the meat industry, the first type is commonly known and includes: computers, process control, automation and identification. I will refer to this type as: *in-direct* electronics. The second type is not so obvious, which is the *direct* electronic input to the animal during processing.

In fact, the *processors* introduce many different electronic inputs to animals as they progress through the processing facility (see §3.1 for details). The introduction of these electronic inputs have mechanical applications such as: Stunning, Immobilisation, Bleeding and Back Stiffening.

There is also the *Electronic Stimulation* of the carcasses which is used to accelerate the rate of pH decline, allowing the rate of pH decline to be manipulated to achieve an *ultimate pH* which is within the industry specifications (Meat & Livestock Australia, 2003).

It is said that: In theory, effective control of pH and temperature decline can provide precise management of meat quality outcomes (Simmons et al., 2006). So there is a significant effort by meat science research institutes world-wide to create ways of accurately controlling the rate of pH decline by controlling the *stimulation profile* and *cooling profile* that is used.

Conventional electronic stimulation equipment used in processing facilities today does not include a *feedback loop* to allow control how much current is applied to each carcass. The stimulation systems are adjusted based on experience and, to a lesser extent, on documented test data (Hviid and Clausen, 2006).

This project the *Smart Stimulation System* uses a feedback system to measure muscle contraction during application. The strength and rate of contraction provides a good indicator to the amount of stimulation needed to produce the best meat quality. (AgResearch, 2005).

The feedback loop measures the response of individual animals to a standard pulse, and then tailors the stimulation parameters to the needs of the particular animal. For example, feedback from the

initial pulse may cause the Smart Stimulation System to deliver fifteen seconds of stimulation to one animal but sixty seconds to another (RuralDelivery, 2005).

This means that every animal can reach its maximum potential, which may be differ from animal to animal (AgResearch, 2005).

3.1 Meat Electronics

As mentioned earlier, there are a variety of in-direct and direct electronic inputs to animals as they progress through the processing facility. This so called *Meat Electronics* field is growing with increasing speed.

Some of the new direct electronic inputs are; High Frequency Stunning, High Frequency Immobilisation, Electronic Bleeding, Back-Stiffening and Stimulation (Simmons et al., 2007; Petch and Gilbert, 1997).

Shown in table 3.1 are some benefits of meat electronics for the processor. While these technologies are in use by many processors, their uptake is governed by many factors but in particular the plant layout can prevent the use of some of these technologies.

Table 3.1: Benefits of Direct Electronic Inputs to Processor (Simmons et al., 2007)

Technology	Benefits
High Frequency Stunning	<ul style="list-style-type: none"> – Enhanced movement control – Improved animal quality
High Frequency Immobilisation	<ul style="list-style-type: none"> – Reduced animal damage – Enhanced safety (Occupational Safety and Health)
Electronic Bleeding	<ul style="list-style-type: none"> – Improved colour – Reduced costs – More blood collection
Back-Stiffening	<ul style="list-style-type: none"> – Reduced chance of spine breaking whilst hide is being removed
Stimulation	<ul style="list-style-type: none"> – pH Control

3.2 Animal Individuality

In many industries, the product variables that the processing facility deals with are controlled so that the product at the end of the process will be uniform and to standard.

The same ideology is followed in the meat industry, but with animals there is an overwhelming amount of variability in the various properties that they have. This is a problem for the producers (farmers) and the processors especially when there is a strong demand for high-quality product from consumers.

3.2.1 Variables

Animals are inherently variable, that is the nature of dealing with wildlife. The key to dealing with the individuality of the animal is to know the important variables, and then implement a strategy for managing them.

The key variable with respect to eating quality and stimulation for the purposes of this report is *glycogen*. (For more information about other animal variables that effect eating quality see the journal of meat science.)

Glycogen is animal starch or sugar, and is held in reserve for stressful events and during strenuous muscular activity (Meat & Livestock Australia, 2006). After the animal is slaughtered, glycogen is the remaining energy source for the muscle.

In the period that follows, the muscles undergo *post-mortem glycolysis*. This is the transformation where the ‘muscles become meat’. The glycogen is converted to *lactic acid*, by a natural chemical process. Over time, the level of glycogen is depleted and a higher level of lactic acid is present (Meat & Livestock Australia, 2006).

The amount of lactic acid that can be present

is dependant on the amount of glycogen that was available before the start of the reaction. There is much research into what factors contribute to reduced levels of glycogen prior to processing, some of the known factors are: Poor nutrition and stress, poor handling during muster, yarding and transport (Meat & Livestock Australia, 2006).

Glycogen concentration levels that are below 0.8g per 100g are said to cause the meat to be *dark cutting* (Meat & Livestock Australia, 2006). Dark cutting meat is a darker colour, coarser texture, lower in tenderness and has a stronger flavour in sheepmeat.

3.3 Controlling Glycogen

During processing, there are some controls that the processor can put in place to manage post-mortem glycolysis. As post-mortem glycolysis is a chemical reaction it is said to obey the Arrhenius Reaction Rate Model. This model describes the high level of dependency that chemical reactions have with temperature: (Fuqua, 1987)

$$\lambda = A \exp \left\{ - \left[\frac{E_a}{k} \left(\frac{1}{T} - \frac{1}{T_0} \right) \right] \right\} \quad (3.1)$$

Where:

λ = rate constant

A = a normalising constant

E_a = activation energy (eV)

k = Boltzman's constant
 $= 8.63 \times 10^{-5} \text{ eV}/^\circ K$

T = ambient temperature ($^\circ K$)

T_0 = reference temperature ($^\circ K$)

It is seen in the Arrhenius equation (eqn 3.1) that the ambient temperature is an important factor in the

reaction rate. In the two extreme cases:

Assuming that A , E_a , k and T_0 are kept constant, then the rate constant can be seen as $A \exp(-\omega \frac{1}{T})$ (for ω representing constants). Where if T is large $\frac{1}{T} \rightarrow 0$ then $\exp(x)$ will become $\exp(0)$ which is $= 1$ and therefore, λ will remain at maximum as time progresses.

If T is very small then $\frac{1}{T} \rightarrow \infty$ so then $\exp(x)$ will become $\exp(-\infty)$ which implies that $\lambda \rightarrow 0$ meaning that the reaction rate will rapidly decrease in an reduced temperature environment.

So if we apply the Arrhenius equation (eqn 3.1) to the conversion of glycogen to lactic acid, then we can see that the temperature dependence is a significant factor in how quickly the glycolysis process takes place in the animal. The factor that the processors have control over is the *cooling profile*, which is controlled by changing the ambient temperature T in the chillers and the rate in which the air is recycled.

The process that is occurring in the chiller is *forced convection*, where the forced factor is the velocity of the cooling fluid in the chiller. Under normal *natural convection* the area between the bodies of different temperature is called the boundary layer (McGraw Hill, 2004). (which is in this case the area between the cooling fluid and the animal). The boundary layer is the region in which the two different temperatures are attempting to find an equilibrium. As the cooling fluid is not under a natural *slow* velocity the boundary layer distance is greatly reduced, thus reducing the time for the temperatures to find their equilibrium.

The model for convection such as this is *Newton's Law of Heating & Cooling*. This law is described as if an object of temperature T_{obj} is placed in an environment of temperature T , then the rate of temperature change of the object is proportional to the

temperature difference ($T - T_{obj}$): (Steyn-Ross, 2007).

$$\frac{dT}{dt} = \gamma(T - T_{obj}) \quad (3.2)$$

where γ is the thermal rate-constant. Now look at the solution of the differential equation:

$$T_{obj}(t) = T + (T_i - T) \exp^{-\gamma t} \quad (3.3)$$

where T_i is the initial temperature, we can see that the rate in which the T_{obj} temperature decreases is determined by the exponential raised to the negative power. As t increases, the rate-constant multiplier γ modifies the rate of exponential decay.

This is the modification that the processor can control. The velocity of the cooling fluid will modify γ . If the fluid velocity \vec{u}_{air} increases, γ will increase also.

As the rate-constant γ can be modified at will, this gives the processor control over the rate of the post-mortem glycolysis reaction.

An illustration of how the reaction rates will change due to temperature is shown in figure 3.1. This shows how the glycolysis reaction rate is effected by the ambient temperature T and the fluid velocity \vec{u}_{air} .

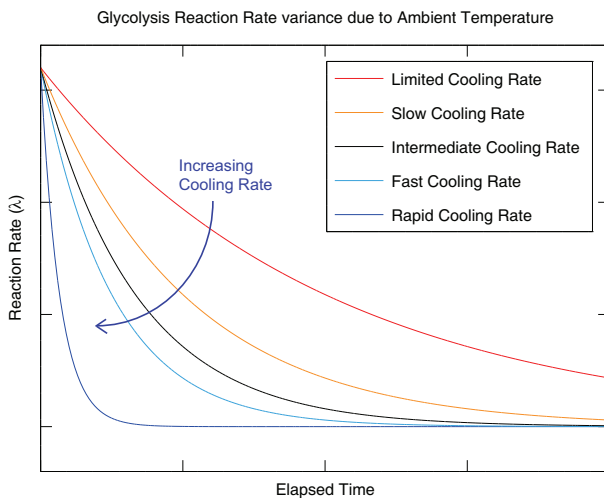


Figure 3.1: Glycolysis Reaction Rate λ variance due to Ambient Temperature T

3.4 Glycogen, Lactic Acid and pH

In the previous section (§3.2.1) about animal individuality and variables, glycogen was discussed. Recall its definition as “animal starch or sugar held in reserve for stressful events and during strenuous muscular activity”.

It was stated that after slaughter, the glycogen remaining in the muscle was converted to lactic acid.

Hannay et al., 2002 state that acids are substances which contain hydrogen ions, H^+ . Acids and bases were first defined by Swedish chemist Svante Arrhenius (1859 - 1927). Arrhenius proposed that acids be defined as chemicals that produce positively charged hydrogen ions, H^+ , in water. (UXL: Encyclopedia of Science, 2006)

Therefore, lactic acid (2-hydroxypropanoic acid) must contain hydrogen ions. Infact it has a hydroxyl group adjacent to the carboxyl group, making it an alpha hydroxy acid (AHA) (Wikipedia, 2008b).

3.4.1 pH

The common method for indicating the acidity of a substance is to state its pH . The term pH refers to a mathematical system developed by Danish chemist Søren Sørensen (1868 - 1939) around 1909. The term pH is used as an abbreviation for ‘power of hydrogen’ (UXL: Encyclopedia of Science, 2006).

The pH scale allows for a relative comparison between substances to evaluate their acidity or alkalinity. This scale is represented with numbers between zero and fourteen ($0 \leftrightarrow 14$), where:

- Acidic solutions have pH values of less than 7.
- Alkaline solutions have pH values greater than 7.
- Neutral solutions have a pH of 7.

pH levels are very important for living things. For example, our human blood has a pH of 7.3. If the pH of our blood is to change by 0.1 of a pH unit, it will cause death (Hannay et al., 2002).

Shown in table 3.2 are some common pH values of items that are found in the household and there are also comparisons to meat.

Table 3.2: Common pH values, with comparisons to Meat. (Meat & Livestock Australia, 2003)

pH Value	Description
14	Strong Alkaline
9 – 12	Common Household Detergents
7.3	Human Blood
7.1	Living Muscle (Live Cattle)
7	Pure Water
5.80 – 6.90	Meat classified as <i>dark cutting</i> ; shelf life decreased; not suitable for vacuum packaging; generally darker and tougher.
5.30 – 5.70	Meat with good visual appeal and potentially good eating quality.
4 – 5	Orange Juice, Beer
2 – 3	Vinegar
0	Battery Acid (H ₂ SO ₄)

In table 3.2 there are a few important things to note: pH 7.1 is the pH of living muscle, pH 5.80 – 5.90 is called dark cutting meat and pH 5.3 – 5.7 is ‘normal’ meat.

It is also important to note that as the lactic acid level in the muscle increases due to glycolysis, then the acidity in the muscle must also increase. This implies that:

The pH decreases after slaughter from 7.1 due to post-mortem glycolysis.

3.5 Why is pH important?

Simmons et al., 2006 state that in theory, effective control of post-mortem pH and temperature decline can provide precise management of meat quality outcomes.

Final tenderness of meat is affected by the rate of post-mortem glycolysis in the muscles (Marsh et al., 1987; O’Halloran et al., 1997).

The theory that is important is the correct control of the glycolysis reaction, by using the correct chilling profile (see §3.3 and eqn’s 3.3 and 3.1 for details).

Meat & Livestock Australia, 2003 state that there is a ‘window’ that the pH temperature decline must go through. The window is described as:

“The animal pH must be greater than 6.0 whilst the temperature is above 35°C and below 6.0 before the temperature falls below 12°C”.

Figure 3.2 illustrates the ‘window’ that is formed by the above statement. It shows where the acceptable zone is, and also where *heat shortening* and *cold shortening* occur.

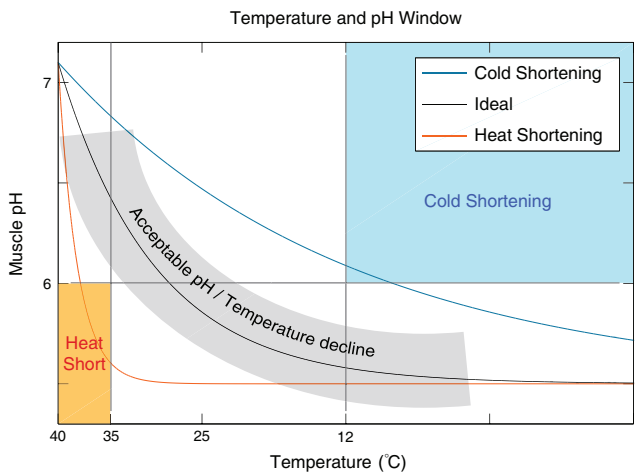


Figure 3.2: pH Temperature decline window

Cold Shortening is a phenomenon that occurs when the pH decline is too slow or the temperature decline is too fast. Cold shortening transforms the meat into extremely tough and dark meat. Cold shortened meat is regarded as inedible (Meat & Livestock Australia, 2003).

Heat Shortening is a phenomenon that occurs when the pH decline is too fast or the temperature decline is too slow. Heat shortening is not as detrimental to the meat as cold shortening, but it is: tougher, pale and watery, has colour differences (“two-toning”) and ageing will not occur (Meat & Livestock Australia, 2003).

Efforts to modify the pH and temperature decline by methods described in §3.3 will produce results as shown in figure 3.3.

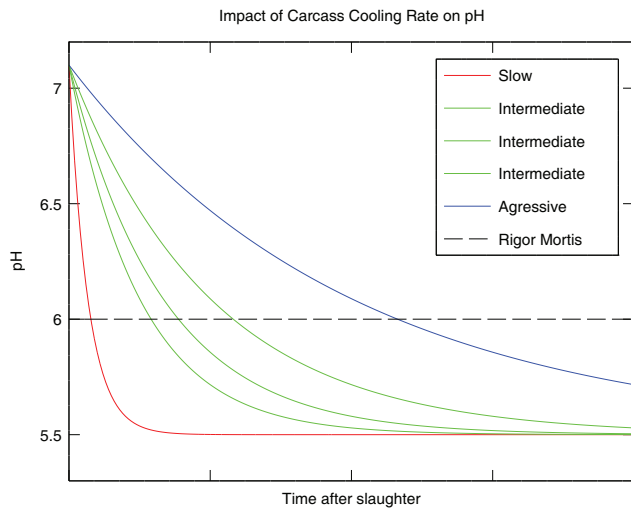


Figure 3.3: The impact of carcass Chilling rate on pH

The equilibrium pH, which occurs either when the glycogen reserves are depleted or if the glycolysis reaction is prevented from completing is called the *ultimate pH*. The ultimate pH is another quantity is measured by the processors, usually in the chillers after a period of the animal entering the chiller.

3.6 Meat Quality

Meat quality is a framework developed by organisations such as Meat and Livestock Australia’s: Meat Standards Australia.

The framework was established to stem the decline of beef consumption by calculating the direct and interactive effects of all factors established as effecting

meat quality (Meat & Livestock Australia, 2003).

The Meat Standards Australia grade is based on consumer testing, where consumers have sampled over 405,000 samples (Meat & Livestock Australia, 2003) and scored them for: Tenderness, Juiciness, Liking of Flavour and Overall Liking.

These results are analysed by first removing the two minima and maxima from each cut and then averaging the best six. The average scores are stored in the database alongside data on the animals: breed, sex, age, growth history, detailed processing data, chiller data, type of cut/muscle, days of ageing and cooking method (Meat & Livestock Australia, 2003).

A grade score is produced specific to each muscle, which allows for retail labels to be attached at the point of sale showing: best cooking method, ageing period and overall quality (Meat & Livestock Australia, 2003).

Meat Standards Australia through research have established that beef with an ultimate pH greater than 5.70 is not acceptable. Therefore: (Meat & Livestock Australia, 2003).

The maximum acceptable pH is 5.70 under the Meat Standards Australia grading system.

The acceptable range is:

$$5.30 \Leftrightarrow 5.70 \text{ (pH units)}$$

(Meat & Livestock Australia, 2003)

It is very important to all involved parties to keep the ultimate pH of the animal within the Meat Standards Australia allowable range.

In Australia the incidence of dark cutting meat is around 10% in beef. That equates to a potential loss of 36 million \$ AUD per year. Dark cutting beef is discounted up to \$0.45/kg (Meat & Livestock Australia, 2003).

The way to avoid dark-cutting meat is by the use of *Electronic Stimulation* which is outlined in the next section (§3.7).

3.7 Electronic Stimulation

Animals are electronically stimulated to accelerate *post-mortem glycolysis* (Strydom et al., 2005). Where post-mortem glycolysis is the physical transition as the ‘muscles change to meat’ as described in §3.3.

Electronic stimulation (sometimes called Electrical Stimulation) is used to prevent cold shortening and dark-cutting meat.

It was said earlier in §3.2 that glycogen is the energy reserve which is used when the animal is stressed or undergoes strenuous exercise.

What electronic stimulation does is strenuously exercises the animals muscles, to the rhythm of electronic pulses. The strength, duration and frequency of stimulation can be adjusted to suit the installation.

An illustration showing the effect that electronic stimulation has on the animal is show in figure 3.4.

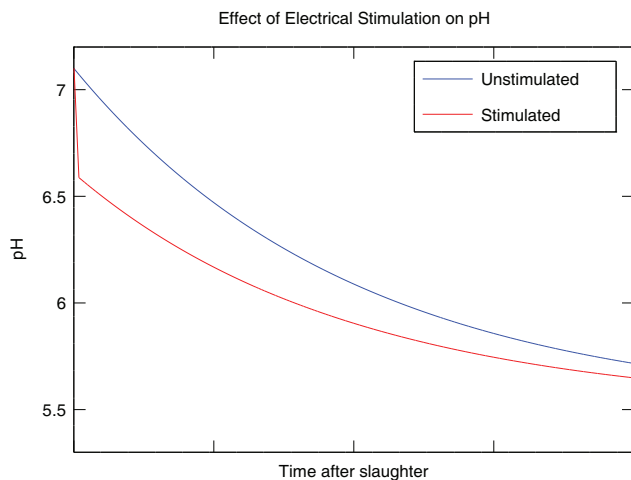


Figure 3.4: The effect of Electrical Stimulation on pH

The effect is that the animals pH is reduced rapidly in a short period of time.

This is due to the animals muscles being strenuously exercised (electronically) and reducing the amount of glycogen that is remaining (no more is being produced). The result is that glycolysis causes lactic acid concentration to increase which decreases the animals pH.

3.7.1 Traditional Electrical Stimulation Techniques

There are a number of ‘conventional’ electrical stunning techniques, one which has been used extensively in New Zealand is a ‘*maximal stimulation*’ whereby the carcass is exposed to a series of 1143 V_p for 90s, which gives a pH between 6 and 6.2 at the end of stimulation (defined physiologically) (Davey and Chrystall, 1980; Simmons et al., 2006).

When the pH reaches approximately six, the contained glycogen is depleted and *rigor mortis* occurs (muscles lose responsiveness to electronic pulses.) (Hviid and Clausen, 2006).

This maximal stimulation is useful for situations where the animal is intended to be rapidly chilled/frozen and a reasonable level of tenderness is achieved (Simmons et al., 2006).

An advantage of this maximal system is that the results are very uniform. But this also only caters for one cooling profile.

With the increase for the need of different cooling profiles such as chilled meat export, a maximal stimulation would be too much and the glycolysis reaction would continue during transport leading to a loss of quality similar to heat shortening.

So *low* and *medium voltage* electronic stimulation systems were developed to deliver a sub-maximal stimulation to allow for some glycolysis to occur after the stimulation period.

Now however, the reliance on the physiological limit

of the animal reaching pH 6 – 6.2 by stimulation is no longer guaranteed. The rate of decline following stimulation is unpredictable (Simmons et al., 1997).

Some of this can be attributed to the difference in glycogen levels that the individual animals possess. Each animal has undergone a different level of stress during the muster, had different nutrition and suffered varying amounts of distress standing in the yards. This will effect the glycogen and therefore pH decline and ultimately the ultimate pH (MLA and Murdoch University, 2000).

3.7.2 Dealing with the Individuality — ‘SmartStim’

As each animal is unique, it responds differently to the electronic inputs it receives as it progresses through the processing facility. Traditional stimulation equipment does not tailor its stimulation sequence to each animal, unfortunately non-ideal prescriptions are given.

This project has been created from the need to give each individual animal a correct prescription of electronic stimulation, which will lead to a more certain meat quality outcome.

The project is an electronic ‘*Smart Stimulation System*’ (dubbed SmartStim) which can individually tailor the stimulation prescription to the animal.

This is done by the use of a feedback loop, which is similar technology to adjusting the amount of gain in an inverting operational amplifier circuit. Except, the means for adjusting the gain is calculated by a complex mathematical operation using data from a myriad of sensors which measure the response of the individual animal from a standard pulse (RuralDelivery, 2005).

The adjustments calculated can make the system vary the strength and duration of the current (AgResearch, 2005). This means that the system can adjust on an individual basis, perhaps delivering 15

seconds of stimulation to one animal and 60 seconds to another (RuralDelivery, 2005).

Further, as the smart stimulation system is controlled by an intelligent computer the target ultimate pH can be set by the processor to match the needs of the particular packaging system, cooling regime and market. The meat is said to achieve ± 0.1 pH units of that figure (RuralDelivery, 2005).

A block diagram of the Smart Stimulation System is shown in figure 3.5 below.

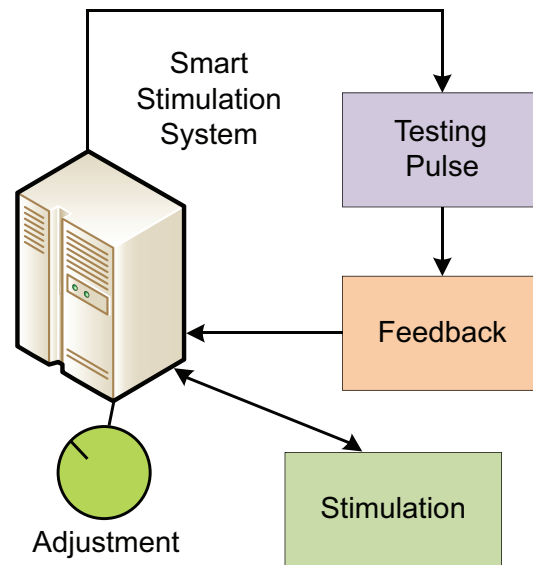


Figure 3.5: Smart Stimulation System

This Smart Stimulation System was developed by AgResearch’s MIRINZ (Meat Industry Research Institute of New Zealand) Centre under contract to Meat and Wool New Zealand and Meat and Livestock Australia (AgResearch, 2005). Carne Technologies are continuing validation studies and installing pilot systems into meat plants in New Zealand and Australia.

The Meat and Wool New Zealand and Meat and Livestock Australia funded Smart Stimulation System is not the only system which is being researched at present.

Marchen Hviid and Ina Clausen who are from the Slagteriernes Forskningsinstitut, part of the Danish Meat Association, talk of a joint Nordic development which is focusing on optimal electronic stimulation (Hviid and Clausen, 2006). Their new equipment can stimulate to meet the individual requirements of the animal, and document that the correct stimulation prescription has been given.

As of November 2006, they had prototype equipment operating at Glide Norsk Kjøtt's abattoir in Rudshøgda, Norway, and they also say that other equipment will become operational at Swedish Meats and a Danish abattoir (Hviid and Clausen, 2006).

This stimulation system is a Nordic cooperation between Swedish Meats, Gilde Norsk Kjøtt and the Danish Livestock and meat board.

So please note that the deliverance of the correct dose of electronic stimulation is very important, and that the world's best meat scientists and electronic engineers are working in conjunction to develop systems to combat this problem.

Chapter 4

Work Placement

Over the summer, I have been working at Carne Technologies Limited in Cambridge. There, work was done on the *Smart Stimulation System* which is jointly funded by Meat and Wool New Zealand and Meat and Livestock Australia.

The Smart Stimulation System is a new type of electronic stimulation system, which incorporates a feedback loop to adjust the stimulation parameters for each individual animal which allows the ideal prescription of electronic stimulation to be given (for detail see §3.7 and §3.7.2).

At present, the Smart Stimulation System and its control system is not integrated either with the installation or the outside world. The lack of integration prevents the potential advanced features that the Smart Stimulation System has to offer.

The project is described as being:

“Information Systems for a Electronic Smart Stimulation System”

This project aims to open the flow of information between the Smart Stimulation System and the outside world. Allowing advantages for the processor, quality assurance, meat science, producer and consumer.

The information that is being talked of is individual animal data including predicted tenderness and predicted ultimate pH (Simmons et al., 2006).

When the system is integrated, this will allow for comparisons of the predictions to the other data

collected by the processor such as: breed, sex, age, dentition, age, marbling and growth–history.

Also at present, while the Smart Stimulation System is being validated, several Carne Technologies Staff members are required to participate in the identification each animal to associate the testing data with the correct animal.

When there is integration with the plant’s animal identification systems, the animal identification number can be automatically associated with the corresponding predictions and testing data.

A smaller team of staff will be required which will save time and money, and allow the team to focus on the collection and comparison of actual and predicted results.

Another task was to create a web interface for a mathematical *meat quality* model. The model has been

written in a proprietary graphical language program which has minimum provisions for people who don’t have their software to view and run the simulation.

Also, there was a need to setup new Smart Stimulation Systems by doing electrical wiring, mounting hardware and testing. As part of this, a *temperature experiment* was conducted to evaluate if the enclosure that was provided is able to dissipate enough heat form the control cabinet.

26	27	28	29	30
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Figure 4.1: Initial plan for the first few weeks of the summer work placement

4.1 Acclimatization

Some time was spent setting up work areas, computer systems and learning some background information about the area of work. Electronic stimulation was not part of my standard repertoire of skills, a certain amount of research and detailed discussions with supervisors made things clear.

There was also opportunity to introduce myself to the other members of staff, who were soon to become work colleagues.

Acclimatization was a small section to the work placement as I was known to the company having done some previous information technology support work for them. Also Carne Technologies is a Medium-sized business. This allowed easier integration into the company, and easier work focus.

4.2 Smart Stimulation System Controller

Initially, the Smart Stimulation System was controlled by a personal computer with I/O modules inserted to extend the capabilities of the personal computer to

control the stimulation system.

It was explained that the personal computers in the harsh environment of an animal processing facility was not ideal. This is due to the high level of humidity and large temperature fluctuations. Even if the personal computers are housed in an industrial enclosure, they are still subject to harsh environmental conditions.

The stimulation system is usually along the *chain* where the animals leave the processing area, and head for the chillers. The temperature on the processing floor is quite warm, whilst near the chillers the temperature is very low. This is the cause for the humidity.

Standard personal computers are not designed to handle this level of humidity, and subsequently the project has suffered problems with these personal computers in the past.

So I was asked to investigate some alternatives to the use of personal computers in these harsh environmental conditions.

There is a number of options for this particular application, whilst still retaining the functionality by the currently offered system. There are three technologies that will offer the functionality to varying

degrees and external packages:

Industrial Computer a computer designed to overcome the environmental factors by sealing and replacing vulnerable technologies around cooling the computer (which normally is solved by vents), this leads to a more environmentally isolated computer which can operate in a harsh environment.

An industrial computer will give us the same functionality as we presently have.

Programmable Logic Controller (PLC) is an automation device used extensively in the control of industrial systems. PLCs are capable of very high level control. PLCs are usually programmed in one of the IEC 61131 languages:

- *Ladder diagram (LD)*, graphical
- *Function block diagram (FBD)*, graphical
- *Structured text (ST)*, textual
- *Instruction list (IL)*, textual
- *Sequential function chart (SFC)*, has elements to organise programs for sequential and parallel control processing.

PLCs are an industrially packaged device, and are manufactured to withstand the demanding environmental conditions that are proposed in the food processing environment. PLCs are used for many applications in the meat processing application.

As PLCs are usually programmed in one of the above ways, this makes it more difficult to implement the desired program. PLCs are usually controlling machinery, dealing with a sequence and making decisions. In our case we will be asking the PLC to do some complex algorithms and many simultaneous calculations. Which may be difficult to implement with the language restrictions.

Programmable Automation Controller (PAC) is an industrially packaged computer system which is the combination of a Programmable Logic Controller and a PC-based control system. PACs have the power of a PC and the industrial build quality of a PLC.

PACs offer an open, modular architecture which allows wide ranging and specialised hardware. PACs are also programmed using generic PC-software-like programming tools which allow for advanced programs.

4.2.1 Choosing the controller

Meetings were scheduled with Allen Bradley, National Instruments and various industrial computer specialists. To find out the advantages and disadvantages of each controller to help decide on what would be the best one to choose.

CompactLogix

The meeting with Allen Bradley's representatives for the Waikato region demonstrated to us the CompactLogix™ series of controllers. This series is a crossover from the original PLC to the latest PACs. It is a small, industrially rated unit (even marine rated) that is programmed in one of the IEC 61131 languages.

The representative made it clear to us that the design of the CompactLogix controller was designed primarily as an automation controller and not as a 'number cruncher'.

He expressed some concern when our research director explained to him the complexities of the algorithm that needed to be implemented, but he did suggest that they did do a rack module which was essentially a computer which could do the calculations for the CompactLogix.

The CompactLogix controller would then do the job.

CompactRIO

The CompactRIO from National Instruments is small rugged industrial control and acquisition system powered by a Field Programmable Gate Array (FPGA) which they call re-configurable I/O (RIO).

NI CompactRIO incorporates a real-time processor for reliable stand-alone embedded or distributed applications with built-in signal conditioning for direct connection to sensors and actuators (National Instruments, 2007b).

The meeting with the National Instruments representative for Australia/New Zealand revealed to us that the CompactRIO was a controller with ultra high performance and customisation that was ample for doing the job that we required.

Figure 4.2 shows the form-factor of the CompactRIO.



Figure 4.2: National Instruments CompactRIO PAC

Industrial Computer

The industrial computer option is the most natural, as it will allow for an easy migration from the current system as it is practically the same except for its form-factor.

Industrial computers are differentiated by their cooling systems, usually the computer has a vent and a fan which applies *forced convection* to the system to increase the cooling rate (γ). This is a ‘breach’ in the outer shell’s defence against environmental factors.

In the industrial computers that we looked at, they were *fanless* and had solid state hard disks. This meant that they used heat sinking (use of increased surface area to dissipate temperature) to keep cool. The advantage of heat sinking is that it does not require a breach in the outer casing of the computer.

FLASH memory hard disks are used as they have a lower heat dissipation compared to normal hard disks, and they can operate at a higher temperature.

An example of the industrial computer’s fanless/heatsink form factor is shown in figure 4.3 below.



Figure 4.3: An Industrial Computer

The large heatsink can be seen along the entirety of the top of the case.

Decision?

The decision was that the best controller for this job was the National Instruments CompactRIO. Reasons for this were:

- Lots of Capability
- Industrial/Marine Environmental Ratings
- Integrated System
- Expandability

But, we didn’t end up using the ‘ideal’ controller, as it happened we were able to use a semi-industrial touch panel computer for the system.

This exercise allowed us to discover lots about what types of controller there were, and to unearth the most

suitable controller. For the next system, this research will help the decision for the next controller.

This may be the CompactRIO.

4.3 Wireless, Virtual Computer Network System

As mentioned earlier in § 4, at a processing facility there are staff being used for the identification of animals whilst the validation process is taking place.

I was asked to investigate a solution into how to avoid this.

The first idea is to get the automated grading station (which assigns the animal identification numbers) to automatically assign the identification number to the predictions and test results.

At this particular processing plant however, the point where the animals are given their identification numbers is *after* where they undergo stimulation from the Smart Stimulation System. This means that there would need to be a buffer of temporary identification numbers and then the real animal identification assigned.

There is also some uncertainty in the consistent order of the animals as they traverse from the stimulation area to the grading area.

For those reasons, it was decided that we would assign our own identification numbers to the animals and record these with the predictions and test data. This is the system that was being used.

To use this system, unfortunately that requires someone to be based at the Smart Stimulation Controller (PC-Based Model) reading the internally generated identification number.

The Smart Stimulation Controller is located up on the gantry in the open roof-space of the processing floor in this particular plant. Which means that

standard verbal communications are not possible. The standard system was to use a *walkie-talkie* (Hand-held Transceiver) radio device to make verbal communication possible.

This system is unacceptable as it can be difficult to understand each other (due to high background noise on the processing floor) and it requires someone to be sitting up in the roof reading numbers out off the screen.

So, the solution for the interim period (until the automated system is figured out) is to create a ‘remote desktop connection’ between a notebook computer and the controller in the roof. This will allow staff to read the number off the screen from the ground. Also, as an added bonus this can give the opportunity to edit the parameters of the controller (particularly good in the validation stage).

The hardware that was used to implement this solution was:

- Wireless NIC (IEEE 802.11a/b/g)
- High gain directional antenna (6dBi/8dBi)
- Wireless equipped notebook

Where a NIC is a Network Interface Card, IEEE 802.11 denotes the standard for ‘ethernet’ networking and 802.11a/b/g designates the different protocols for wireless ethernet networks.

The software that was used is RealVNC, which is a free Network Computing (NC) client/server software package that can be installed on the operating systems that are being used. This software and a network connection the requirements for Virtual Network Computing (VNC).

Network Computing started form the X Window System (UNIX) allowing users to access their computers from remote locations. This was a great leap in the mobile computing world, but this has changed a lot since those days. Now, VNC is a very simple,

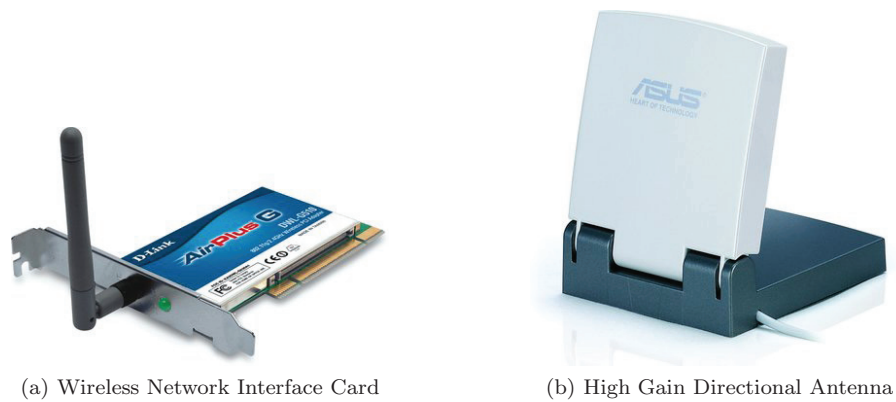


Figure 4.4: Hardware for Virtual Network Computing

fast protocol which is independent from the operating system. This has allowed VNC to provide a fast and powerful user interface (Richardson et al., 1998).

The wireless network interface card and the high gain directional antenna were installed in the Smart Stimulation controller computer, and then the Transmission Control Protocol/Internet Protocol (TCP/IP) settings were adjusted so that the Internet Protocol (IP) address of the controller had the same network address, which in this case for a Class C IP address (first 8 bits of IP address are between 192 – 223) means that the first three octets (set of 8 bits) are the network address (Cisco Systems Inc., 2003).

(N.N.N.C) where N represents a component of the Network address and may range from 0 – 255, and C represents the client address. (for a Class C network.)

Once the network traffic blocking firewalls were turned off, communications were tested by the *ping* command at the MS-DOS command prompt. When the connection was established, RealVNC client was installed on the *viewing* computer and RealVNC server installed on the Smart Stimulation controller (*server*) computer.

After a simple password authentication, Network Computing is successful over the wireless ethernet

network.

This testing phase was conducted at Carne Technologies rather than in the harsh environment of the meat plant.

When the system was working to satisfaction, the Smart Stimulation controller was re-installed and an ‘on-site’ test was carried out.

The system worked just as we had trialed, and the process of validation was made one step easier.

There were a few problems with the direct current (DC) power supply that the controller was powered by and this continues to be an intermittent fault which we believe is due to the power supply failing to supply enough current on computer start-up.

Detailed instructions were created to help those who were going to use the system, and this can be found in the appendix.

Pictures of the hardware which was used to enable Virtual Network Computing can be seen in figure 4.4.

4.4 Remote Access

This is the most important part of the work placement. The idea of *remote access* is to collate the data for the individual animals which is being generated by the Smart Stimulation System, and store this at a central node on the network.

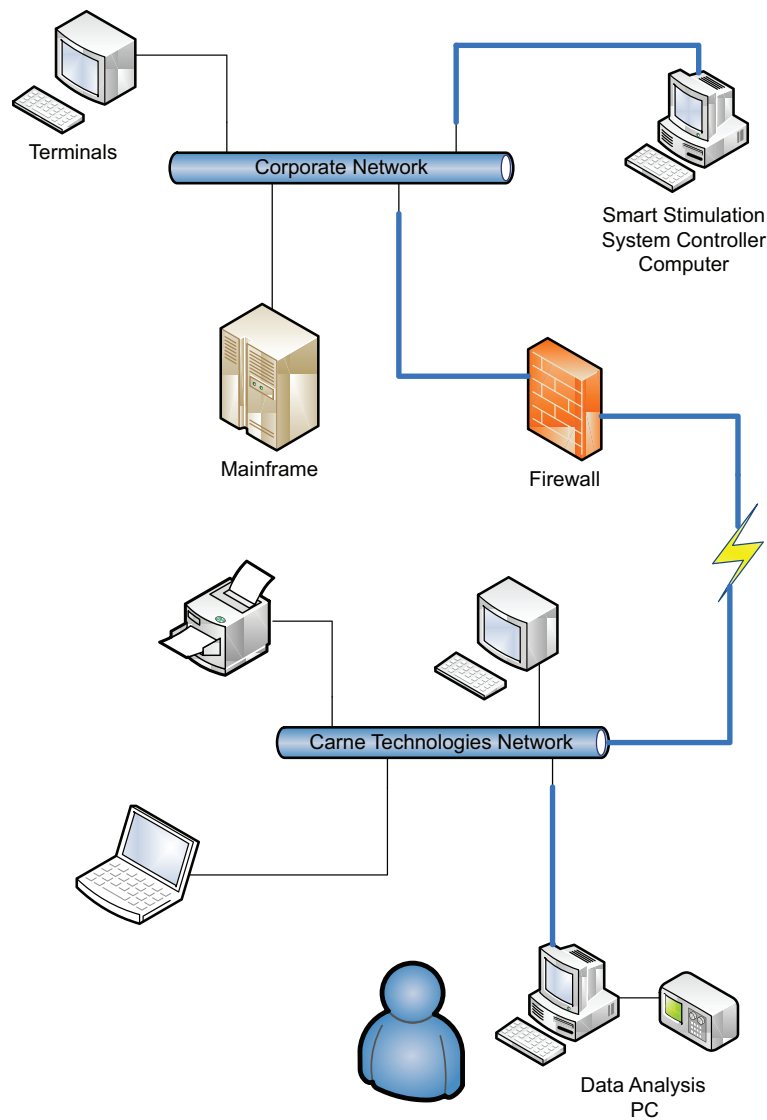


Figure 4.5: General connectivity diagram between Smart Stimulation System and Carne Technologies

The flexibility that this system can give is described as below:

Remote access is a two part system, which consists of central data storage and the ability to make modifications to the Smart Stimulation Controllers from remote locations.

Storing the data centrally will allow for analysis from Cambridge, which will enable the pathway for automatic validation/calibration ‘runs’ in the future.

Remote Modification gives the opportunity to make ‘live’ changes to the Smart Stimulation controller computer, giving simple adjustability and on-line observation or troubleshooting.

The pathway for remote access is as shown in figure 4.5, highlighted in blue. There needs to be a link between the Smart Stimulation controller computer and the computer which is going to connect remotely in order for the remote access to function.

However, the inclusion for a network link between the Smart Stimulation System and the Internet was not

part of the original specification, so there is a lack of pre-prepared infrastructure for communications at the installations.

4.4.1 Pilot Installation

It was decided that first, the remote access idea should be implemented at one installation to evaluate its real advantages and to discover the road for full-scale implementation.

The processing plant that was chosen, was selected for its locality. It is in relative close proximity to Cambridge/Hamilton. This allows multiple trips troubleshooting, which is sensible when implementing a new system.

We embarked on a road-trip to this processing plant to establish the current situation of the Smart Stimulation System and to check the corporate network infrastructure that existed on-site.

Again, the Smart Stimulation System controller computer is located in the roof-space above the processing floor. This time, topside of the suspended ceiling. This location is a much more stable environment for the computer to be running in as it is a reasonably stable atmosphere.

However, this location is not ideal for inclusion into the corporate infrastructure.

Firstly, I tried to detect a wireless access point from this location as this approach does not require any new infrastructure but the signal is too weak, potentially knocked out by the substantial amount of ironwork in the roof in the direction of the transceiver.

So we decided to ‘run’ a four twisted pair cable to the corporate network at the processing plant.

The cable which was chosen to be run is called Category 5e cable. This cable which was defined in ANSI/TIA/EIA-568-A, is the ‘standard’ computer networking cable at the present time. It

enables a 100Mbit s^{-1} ethernet connection called 100BASE-T/TX (Cisco Systems Inc., 2003).

This proved to be a major setback to enabling the remote access goal during the realm of this work placement.

Meat processing facilities usually have a small engineering staff on-site, who are primarily employed for maintenance tasks. When asked to do tasks, they are generally eager to help but they have a limited time frame for doing non-maintenance tasks.

The cable running job was actually a major job, as the nearest network switch was multiple floors, several rooms and many meters away.

When the cable installation was complete, we travelled to the processing plant to put Registered Jack 45 (RJ45) connections on either end of the cable. The Cisco Certified Networking Academy (CCNA) training greatly helped to connect the cables to the specification. A diagram on the colour coding of the Telecommunications Industry Association/Electronic Industries Alliance-568-B (TIA/EIA-568-B) connection is shown in figure 4.6.

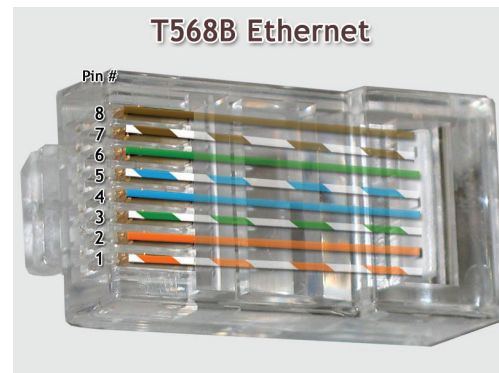


Figure 4.6: TIA/EIA-568-B cable connection of a Category 5e cable into an RJ45 connector (Image Courtesy of: blog.smartechome.com/index.php/wiring)

A TIA/EIA-568-A standard connection is similar, but the orange and green pairs are swapped in pin location.



Figure 4.7: The Fedora logo (Image Courtesy of: <http://fedoraproject.org/wiki/Logo>)

A cable with a ‘568–A’ connection on one end and a ‘568–B’ connection on the other is called a *crossover* cable. Crossover cables are used to network two **like** network devices such as two computers or two network hubs (Cisco Systems Inc., 2003).

A cable with two identical ‘568–A’ or ‘568–B’ connectors on each end is called a *straight-through* cable. The straight-through cable is used to network two **un-like** network devices such as a computer to a network hub (Cisco Systems Inc., 2003).

In this case, a straight-through cable was used as the Smart Stimulation controller is connecting to a corporate network hub (switch). TIA/EIA–568–B connections were used on each end (this is a pseudo-standard, two ‘568–A’ connections would be fine too).

After the connections were made the connection was tested by logging into the corporate network’s proxy server which forwards the requests to access the Internet on this network. We had previously sought password authentication from the IT department.

The connection was successful, and Hyper Text Transfer Protocol (HTTP) communications over Port 80 allowed Internet browsing.

Due to the setback in the cabling of many weeks, this was the extent of the on-site work for remote access at this pilot installation.

4.5 Data Storage

This section focuses on the setup of a protocol for data flow and how it should be stored.

The ideal system would be for each of the Smart Stimulation Systems to automatically transfer their accumulated data over the Internet to the data storage computer.

After looking at our companies IT development programme however, it became apparent that the company was looking at launching a website. With web hosting comes web storage and file transfer protocol (FTP) access to this storage space. By modifying the ideal system to include an intermediate node (the web server), the company is able to save money by utilising the static IP address that the web server has.

To access a computer, it needs to either have a static IP address or is part of a domain name server (DNS) which dynamically assigns an IP addresses and ‘links’ them to a domain name.

Taking advantage of the web server’s static IP address enables the Smart Stimulation System to deposit its accumulated data and it also allows for web site storage in the future.

We contacted the web hosting company, and discovered that we already had a domain reserved due to using e-mail with them. It was a simple process to change ‘plans’ to one which had web hosting.

An old Windows machine was migrated to the Linux — Fedora Core platform, the Linux platform provides a stable and robust computer for the collation

of the data. Also a lot of software for the Linux kernel is open source or available under the general public licence.

To access the FTP web server, at the terminal the command `ftp xxx.xxx.xxx.xxx` is typed at the prompt. There is a prompt for username and password authentication and then the connection is established. Once connected, it is as if the file system is that of the FTP folders on the web server plus the local FTP folder.

Files can then be transferred to and from the local FTP folder by the commands `GET` and `PUT`. An example of this is shown below.

```
>ftp xxx.xxx.xxx.xxx
connecting to xxx.xxx.xxx.xxx ... ..
username: 1234 !example only!
password: 5678

login successful.

ftp>ls
.  data  web_docs  ht_docs

ftp>cd data
ftp\data>ls
ss_data_01.dat  ss_data_02.dat

ftp\data>get ss_data_01.dat
get successful

ftp\data>put calibration_info.txt
put successful

ftp\data>ls
calibration_info.txt  ss_data_01.dat
ss_data_02.dat

ftp\data>cd \
ftp>bye

>_
```

Figure 4.8: Example FTP connection and transfer of files

This process can be automated by writing a shell script later.

4.5.1 Smart Stimulation Software

On the other end of the data transfer process is the Smart Stimulation System. Which at present does not automatically send its accumulated data via FTP.

The software that is controlling the Smart Stimulation System is written in LabVIEW.

LabVIEW is not a usual computer programming language like `C`, `C++`, `C#` or `Java` but is a powerful, graphically interfaced programming language used extensively by scientists for integrating instruments with computers.

LabVIEW has the provisions to send its accumulated data by FTP to a web server, but this is not a current segment of the code.

During the course of the work placement, we worked with the company that had written the software to enable this capability to send files via FTP.

At the end of the placement this was not yet complete.

This was largely due to the software engineer that was working on the project taking leave to attend a wedding from November → Mid-February.

So in-essence, we had only a limited time available (approx one week) to work with the software engineer. Before this the other staff at the software company did their best to satisfy our needs, but they had a focus on preparing the new system for another installation.

4.5.2 Database

Presently the data is stored in *discrete* files. Storing the data in this way is an inconvenient way to store data, as the data cannot be accessed simultaneously.

A database is an organised collection of information stored in a logical tabular format. This is a similar manor to a spreadsheet, as the data forms in *fields* which is similar to cells under columns.

As mentioned in the introduction to chapter 4 and later in §4.3 on the Wireless Virtual Networking System, the goal was to integrate the Smart Stimulation System into the processing facilities network and acquire the animal identification data.

Carcass ID	Tenderness	pH	Ultimate pH	Grade	Sex	Weight	Testing Data
3552	B	5.8	5.6	A	M	982	0.078127 0.003906 0.011719 -0.011719 -0.023438 -0.027345 -0.015625 -0.058596 -0.003906 -0.007813

Figure 4.9: Smart Stimulation Data organised in a Database format

It turns out that there is the opportunity for more integration with the processing plant's network than just using the animal identification number. There is the opportunity to share: breed, sex, grade, weight and many other factors.

If there is the inclusion of these other factors then this gives the ability to draw further conclusions and research.

An example of the database which is talked about is shown in figure 4.9. This shows the clear organisation of the data under the individual field headings, and also how the data is clearly identified with each *record* if there were multiple entries.

A feature of databases is their ability to be *queried* for information that matches the query criteria. Records in the database can be isolated due to this matching of criterion. Queries allow easy reference for comparisons, or can be used to select records that require further action.

In this project there is the potential to use the predictions for pH that are obtained to prevent the manual measurement of all animals which happens usually. For example, the query could be used to identify the animals with a predicted ultimatepH above a certain value minus the accuracy of the prediction and a margin of error.

The prediction may allow processors to only

measure previously identified 'high-risk' category animals for accordance with the specifications such as Meat Standards Australia's grading system. Instead of each animal being measured, only a small number who are likely to be around the grade specification cutoff would be measured.

4.6 New System

There was the need to build a new Smart Stimulation System for another installation in a New Zealand processing facility. The team was assigned the task to assemble and install the equipment into the control cabinet.

Arvin Pitt was assigned to do the mounting of the equipment and the initial control cabinet wiring.

This job required processes of marking out the locations of the mounting holes, drilling these holes, affixing the hardware with self-tapping screws and routing the cables in the cable trays.

The completed hardware installation and preliminary wiring is shown in figure 4.10.

As you can see there is a large 'panel-computer' inside this box, this is the Smart Stimulation System's processing hub. The problem with this is that with computers there is a large amount of heat created.

So I was asked to conduct a 'temperature exper-

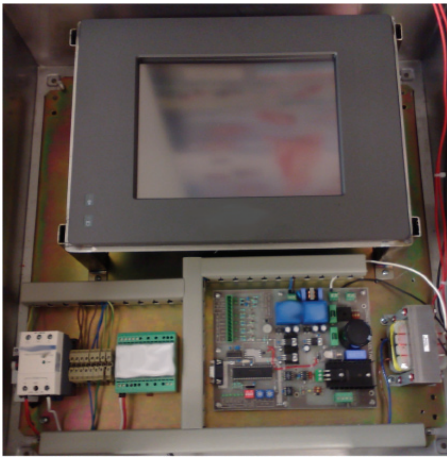


Figure 4.10: Control Cabinet wiring

iment’, to analyse the temperature that the control box achieves under normal operating conditions, in a variety of different ambient temperatures.

The temperature experiment is outlined in § 4.6.1.

4.6.1 Temperature Experiment

The temperature experiment is to observe the temperature increase in the control cabinet whilst the control equipment enclosed is operational. As you can see in figure 4.10, the control cabinet consists of a panel-computer, power supplies and other electronic circuits.

Each of these electronic devices dissipates a certain amount of heat. The largest heat dissipating device is the panel-computer as it consumes the most energy around 90 W.

Electronic component reliability is proportionate to the temperature of the environment that the component is in. In fact, the reliability obeys the Arrhenius reaction rate model eqn. 3.1 (Fuqua, 1987).

So for reliability and longevity the electronic devices should be in the lowest ambient temperature T possible, or at least well below the maximum rating for temperature.

The temperature experiment consisted of running

the system for one hour, as this was expected to be enough time to reach the equilibrium temperature. While the system was running, a temperature logging device was placed inside the control cabinet.

The temperature logging device that was used was manufactured by Arvin Pitt in Digital Electronics 211 as part of a university laboratory session. The circuit consists of a ZiLOG micro-controller, RS-232 controller and a thermistor.

The resistance values from the thermistor are sampled by analogue to digital conversion, and then given a decimal representation for temperature in °C. The temperature values are sent via RS-232 to a computers serial port.

The temperature logging circuit is connected to a computer, and the temperature values are streamed serially. This text transmission is available for access via HyperTerminal. The program in the micro-controller gives options for reading single or continuous temperature values.

The continual stream of text values can be ‘captured’ by using the capture text function within HyperTerminal. The results are shown in the figure 4.11 on page 27.

There has not been any numerical analysis on this data yet, but there are some conclusions that can be drawn. The overall trend follows that of Newton’s Law of Heating: (from § 3) (Steyn-Ross, 2007.)

$$\frac{dT}{dt} = \gamma(T - T_{obj}) \quad (4.1)$$

The solution of the differential equation is:

$$T_{obj}(t) = T + (T_i - T) \exp^{-\gamma t} \quad (4.2)$$

The situation involves a heater and an ambient temperature, which is the situation of forced convection

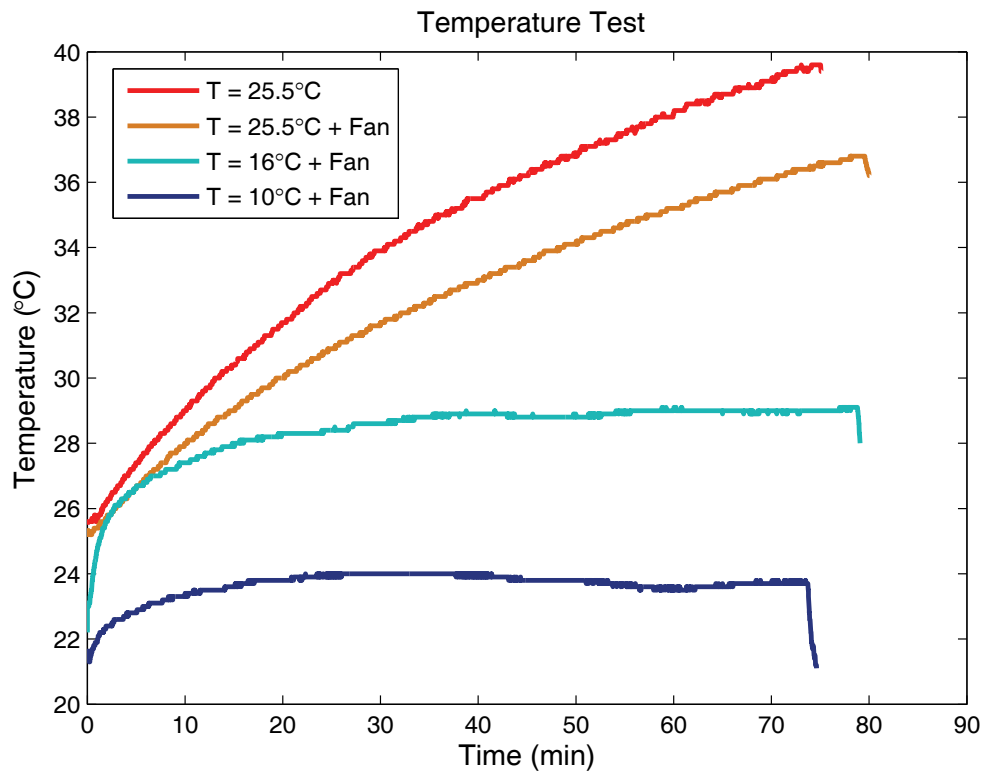


Figure 4.11: Temperature experiment raw data from logger

but in the opposite sense. Also the results with a ‘+ Fan’ have an extra fan turned on the inside which increases air flow thus also forcing conduction.

From these results, further analysis will be able to extrapolate the trends and find the ambient temperature that is required to keep the control cabinet at a comfortable temperature. Or, this can enable decision on if additional heat sinking is required.

4.7 Meat Quality Model – Web Interface

The objective was to create a web interface for the meat quality model. The idea is to provide a Rich Internet Application (RIA) which will allow users to change simulation parameters and see the results displayed on a results page.

The meat quality model was written in a proprietary, visual programming language which has no current support for displaying an interactive web interface.

So, I explored the option of taking the formulae from the model and creating a new model using a standard programming language for Internet applications such as JavaScript. But to rewrite the meat quality model would be quite a task.

Therefore I approached the software company who produces the simulation software, asking for a method in producing a web interface models created in their software package. Their answer was that they have another software package, made especially for creating interfaces for their simulation models.

But, currently there is no runtime engine for Internet explorer for the interfaces that are made. They did inform that this was being worked on, and is

nearing completion.

So, it was decided to create an application interface in the simulation companies own interface building software.

The design of the interface is given in the figure 4.12.

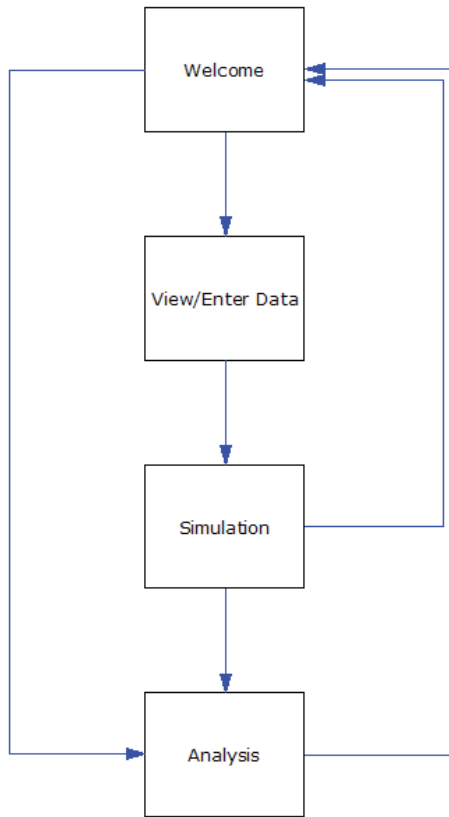


Figure 4.12: Interface Design Flowchart

This model was chosen as it is the recommended method for producing the interface by the software company. The method suits the interface design software as the various parts of the program are created on *screens*. A screen can be thought of as a ‘page’, which users have access to one screen at a time.

There are also *mini-screens*, which are re-sizeable and floating displayed on top of screens. Mini-screens are primarily used to display results.

The welcome/enter data screen is shown in figure 4.13. This is the first screen displayed when the interface is opened. This screen gives the user a place to enter the simulation parameters, run the simulation and view the results.

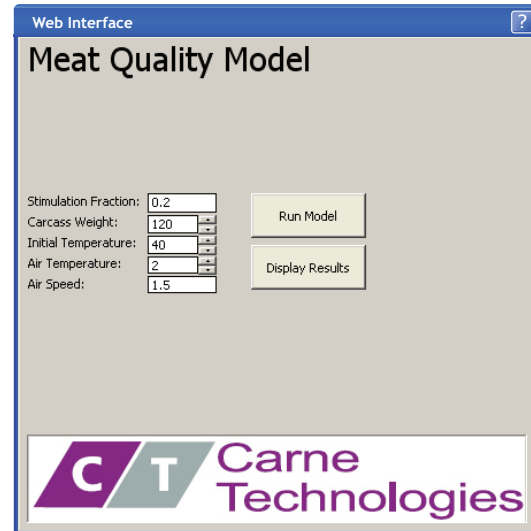


Figure 4.13: Meat Quality Model – Enter data

When the simulation is run, the calculations are done and results displayed on a mini-screen when the display results button is clicked. This brings up a window which looks like the one shown in figure 4.14.

After the runtime engine for Internet explorer is complete, the interface can be inserted into any web page. This gives the level of inter-activity that is desired.

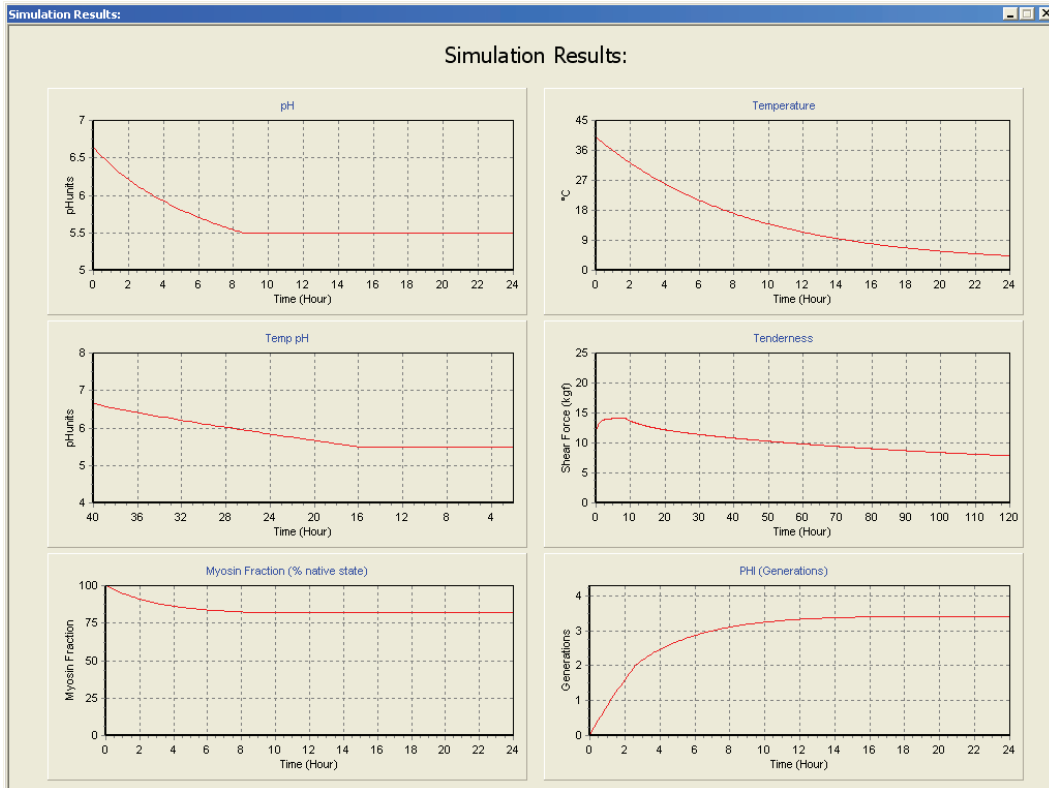


Figure 4.14: Meat Quality Model – Results screen

Chapter 5

Conculsion

⋮

Glossary

Carne Latin for meat, 1

Chain chain-like mechanism which transports the animals inside the processing facility., 14

Cold Shortening pH decline too slow / temperature decline too fast. Results in extremely tough meat and dark colour., 7

Dark Cutting meat characterised by dark colour, coarse texture, reduced tenderness and sometimes a strong flavour., 5

Forced Convection similar to natural convection, but the cooling fluid's velocity is now controlled which increases the rate of heat transfer., 5

Glycogen is the primary short-term energy storage in animal cells., 4

Heat Shortening pH decline too fast/ temperature decline too slow. Increased toughness, pale soft exudative and ageing will not occur., 7

Post-Mortem Glycolysis happens to meat after slaughter, the conversion of glycogen to lactic acid., 4

Processors companies who process animals from arrival on stock trucks to delivery of retail packages at supermarkets., 3

Producers the farmers, people who raised the animals, 4

Smart Stimulation System An electronic stimulation system that adjusts its prescription to match the needs of each individual animal., 10

Ultimate pH pH achieved after a time period has elapsed and the glycolysis reaction has ceased., 8

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