A Nuffield Farming Scholarships Trust Report

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The Utilisation and Impact of Robotics on Large Scale Dairying

Alisdair Cook

June 2023

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A Nuffield (UK) Farming Scholarships Trust Report

Date of report: June 2023

"Leading positive change in agriculture. Inspiring passion and potential in people."

Title	Utilisation and impact of robotics on large scale dairy farming
Scholar	Alisdair Cook
Sponsor	The MacRobert Trust
Objectives of Study Tour	1) To assess the feasibility of utilising robots on a large scale. 2) To determine whether robots are a financially viable option. 3) To determine best practice whilst utilising robots.
Countries Visited	Canada, USA, Netherlands, Germany, Chile, Argentina
Messages	1) Robotic technology (RT) appears to be a viable option for the large-scale producer. 2) A decrease in labour costs combined with higher milk yield and a reduction in replacement rates results in a financial gain when using RT. 3) When operating on a large scale; a 'milk first' guided system appears to be the most efficient system.

EXECUTIVE SUMMARY

Dairy farms are having more issues than ever sourcing labour. The biggest issue observed in my travels was attracting milking technicians into the industry. As the UK moves more towards the US model of fewer farms of a greater size, this problem is only going to be exacerbated here in the UK.

The aims of this study were threefold:

1. Is robotics a viable option for large dairy farms?
2. Are they a financially viable option?
3. If so, what is best practice when designing layouts and utilising robotics?

During my study I visited the USA, Canada, Chile, Argentina, the Netherlands, and Germany. All countries are either at the forefront of robotics or major players in large scale dairying.

Operating box stall robots result in an increase in milk yield of between 3% and 10%, depending on the previous system. Evidence from these farms shows a reduction in replacement rate of up to 5%. Both these efficiency savings combined with a labour saving of up to 40% on large farms result in a net financial gain after robotic implementation.

Many different layouts and configurations exist for box stall robots. The most efficient system observed on my travels was a 'milk first' guided traffic system. Where cows are 'guided' around the system by the removal and presentation of certain inputs at certain times. These systems appear to result in lower pellet usage within the robot, a lower rate of fetch cows and allow a greater number of cows per robot due to preselection of certain cows.

Robot depreciation has in the past been a factor in the lack of uptake of the technology. However, there is a strong second-hand market for robots and diverse ways of financing exist to keep costs under control. Maintenance and servicing are key to extending the life of robots, with many reported as exceeding 10 years in operation.

Other robotic technologies such as feed pushers and manure collectors are more difficult to financially justify. They also still struggle to handle sand-laden manure which is often present on large dairy farms. Fully robotic rotary development appears to have stalled, with a greater emphasis now on utilising robotic arms on conventional rotary parlours.

The conclusions I have drawn from my study are that utilising robotics on a large scale is financially viable due to an increase in milk yield, a decrease in staffing costs and a reduction in replacement rates. To ensure optimal functionality, the equipment must be maintained and serviced to a high standard. Farmers should be thinking as to how robots will integrate into their businesses in the future, even if they do not plan to use them initially.

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All monetary values are expressed in GBP (£) and were correct at the time of the report.

Please note that the content of this report is up to date and believed to be correct as at the date shown on the front cover.

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Chapter 1 - Personal Introduction

Having come from a non-agricultural background, my route into farming was more unconventional than most. My interest in dairying was first aroused at the age of five when I started 'helping' at the dairy farm next door to where I lived. It was not until working part-time during university though that I thought of dairy management as a career option.

After graduating from the University of Stirling with a Sports and Exercise science degree, I embarked on a summer of work experience in two large dairies in Wisconsin. Under the tutelage of dairy guru Kenn Buelow, my interest in working with large numbers of cattle and managing teams of people was enhanced.

On my return in the summer of 2011, I started a role as herd manager on an 800-cow dairy. This was following by 18 months working in Saudi Arabia for Almarai dairy company. The farm I was on milked 25,000 cows four times a day along with rearing 20,000 head of youngstock. The experience of working here opened my eyes to the challenges of managing large numbers of people.

My current role is as Dairy Manager on a 1,550 head dairy farm in Southwest Scotland.
Outside of work, I enjoy spending time with my wife Rachel and two daughters Emily and Isobel. I also run a small pedigree herd of dairy cattle that takes up any remaining surplus time!

Chapter 2 - Background to my study subject

2.1 Introduction

Post Brexit, labour availability on dairy farms and especially large ones has become an increasing issue. Dairies that have built themselves up off the back of abundant and cheap Eastern European labour have found that post Brexit, this source was no longer available. I wanted to find out whether robots were not only a solution for this labour shortage but also whether they were a cost-effective solution.

2.2 Current UK herd size demographics

The number of Scottish dairy producers has seen a decline year on year for the last ten years as shown in figure 1 below, there is a similar picture across the whole of the UK. The same graph also shows that overall cow numbers have remained relatively unchanged in that same period. It shows that the average dairy size has increased over that same period. What the evidence also shows is that the number of dairies that are milking more than 750 cows continues to rise (figure 2).

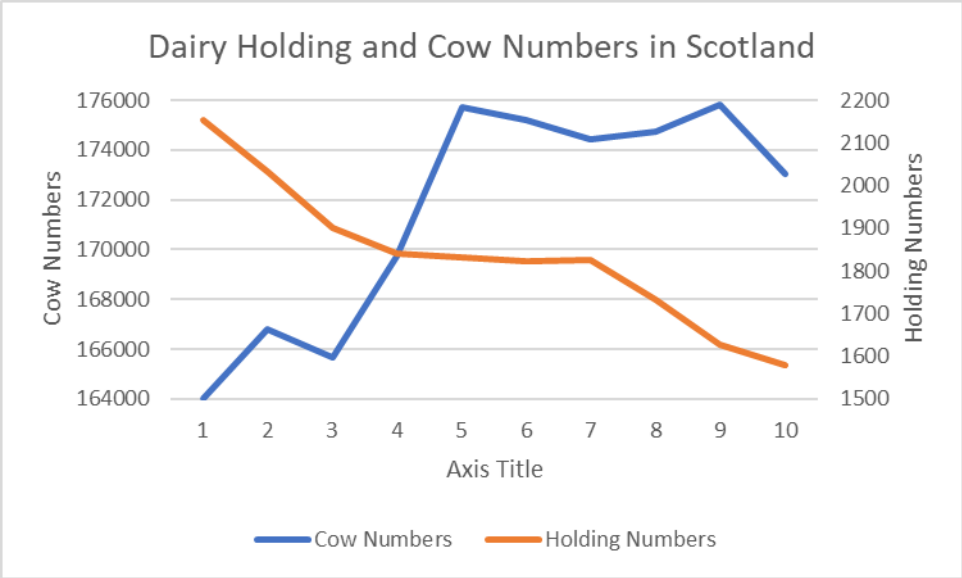


Figure 1: Dairy holdings and cow numbers in Scotland.
Source: Authors own graph, from Scottish Government and AHDB data.

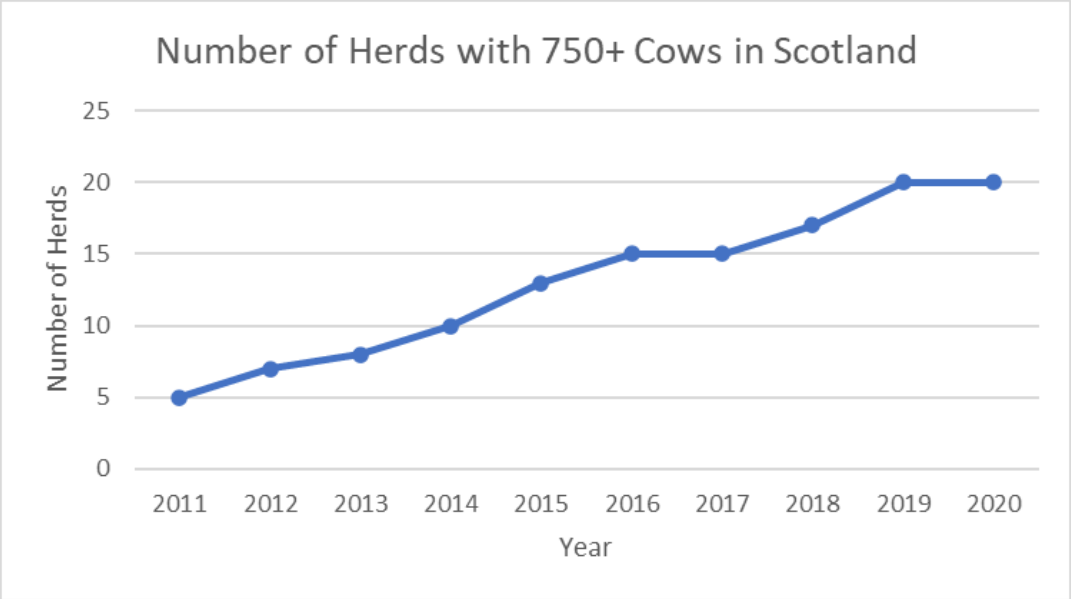


Figure 2: Number of herds with more than 750 cows in Scotland.
Source: Authors own graph, from Scottish Government and AHDB data.

2.3 Situation in the USA

It is well documented in the USA, that half of all labour employed on US dairy farms is utilised to harvest milk. As the UK increasingly moves towards this model of larger and fewer herds, the amount of labour dedicated solely to the milking process will increase. It is this labour that is difficult to attract and therefore robots are an attractive solution.

A striking example of how even US businesses are struggling to source and retain labour is nicely encapsulated below. This simple exercise reveals that labour related issues are more of a concern than input costs, even during a time of spiralling inflation to dairy employers.

World Dairy Expo stall showing glass jars with labels left to right: labour, regulation, federal order system, input costs, sustainability, and labelling. Photo: Author's own.

Summary

- Post Brexit labour availability in the UK has become a greater issue.
- UK herd demographics show a continued shift towards larger herds.
- Producers see labour as potentially more of an issue than input costs.

Chapter 3 - My study tour

My Nuffield travels took me to some of the major dairying heartlands of the world. Below is the table of where, when, and why I visited each country.

Where	When	Why
Canada and USA	May 22	Although Canada has historically been the home of smaller farms due to their quota system, a few larger operations do exist. This trip allowed me to visit some of these along with a large dairy in New York State using a fully robotic rotary.
USA	September/October 23	The USA is renowned for being at the forefront of large-scale dairy management. I was intrigued to see how they were using robotics within their systems. I also used the opportunity to visit the World Dairy Expo to discuss with manufacturers what was in development.
Germany and Netherlands	November 22	I was interested in visiting large dairies in the west of Germany along with the Lely Robotics factory in the Netherlands.
Chile and Argentina	February 23	Ancali dairy farm in Chile is the largest robotic dairy in the world. I was keen to see why they and other farms in the region were operating robots in an area where labour has historically been plentiful and cheap.

Chapter 4 - Health and welfare benefits of box stall robots

4.1 Health and welfare benefits

All the farms that I visited throughout the world reported an increase in milk yield after adopting box stall robots. The percentage increase ranged from 3% to 10%. A conservative estimate when transferring from a three times per day conventional milking system would be 3%. All farms also reported a reduction in replacement rate. However, this could be due to the cows entering a newer more cow suitable designed shed at the same time as the robots were installed.

The Turchi Family with the author, Trenque Lauquen, Argentina. Photo: Author's own.

4.2 Case Study: Drumgoon Dairy

The first things that strike you about Rodney and Dorothy Elliot are their incredible business acumen and their infectious attitude to life. Having sold their farm and 140 cows in county Fermanagh Northern Ireland in 2006, they emigrated to South Dakota to start a new life. At the time, the State was trying to encourage outside investment into agriculture and so, along with some risk capital investors, they started milking 1,400 cows on bare land with all inputs purchased in. By 2019, the herd had expanded to around 5,000 cows being milked through two parlours.

Although they had a stable management team and herds' people, the Elliot's found milking staff retention difficult. Therefore, for their next expansion, they decided to milk an additional 1,400 cows in an adjoining facility through 20 Delaval milking robots. The cows in this barn could be looked after by two full time members of staff (excluding calving and feeding duties), which was estimated to be around a threefold reduction of what would be required in a conventional facility of this size. Early figures from Drumgoon East are showing an increase in milk yield by around 10% and an increase in cow productive lifespan from 2.1 to 2.4 lactations.

At the time of my visit in September 2022, the Elliots were in discussion with neighbours to set up a new facility using 50 robots.

The author and Rodney Elliot. Photo: Author's own.

4.3 Case Study: Agrargenossenschaft Memmendorf

Like many dairies in the east of Germany, Agrargenossenschaft Memmendorf consists of large concrete sheds from the late Soviet Era of the 1980s. The narrow passageways and tight turns were far from ideal for the modern Holstein cow trying to make its way to and from the rotary parlour three times per day. Sixteen robots were retrofitted around five years ago and have allowed the facility to extend its lifespan by a number of years. It was reported that since installation of the robots, the replacement rate on the farm had dropped from 40% to around 30%.

Agrargenossenschaft Memmendorf, Dresden Germany. Photo: Author's own.

Summary

- Box stall milking robots result in a milk increase of between 3 and 10% depending on implementation.
- They can result in a lower replacement rate due to a reduction in trips, slips and falls associated with a conventional parlour system.

Chapter 5 - Best practice utilising box stall robots

5.1 Layouts and systems

It became apparent early on in my travels that there were two distinct philosophies around box stall robot layout. These are known as ‘free access’ and ‘guided traffic’ systems.

Free access systems allow the cow to fully decide on her routine and how and when she accesses the robot. These systems are promoted by those looking to minimise cow touches and allow the cow to fully express her natural behaviour.

Guided traffic systems restrict the cow’s access to certain inputs at specific times. To access the milking robot, the cow must first pass through a selection gate. This gate determines if the cow has milking permission or not. After milking, or if access permission is declined, the cow gains access to the feed passage but has no access to water or a free stall. To gain access to these, the cow must pass through a non-return gate, after which the cycle starts again. Promoters of these systems point to the fact that cows are not driven to the robot by pelletized feed but by a total mixed ration at the feed fence. They also point to the fact that these systems have a lower rate of ‘fetch cows’. These are cows that have not come to the robot of their own accord and must be collected a couple of times a day.

A quick comparative between the two systems is shown in table below.

	Guided and Semi-Guided	Free Access
Cow Per Robot	62-70	52-56
In Robot Pellet Fed	2-8kg	5-10kg
Fetch Rate	3%	3-10%
Cost of Setup	Higher due to extra sort gates and non-return gates	Lower

Table showing difference between both philosophies of milking systems as seen on my study tour.

Professor Trevor De Vries and the author at Elora Dairy Research Facility, Guelph, Canada, where we discussed their latest research into robotic systems and layouts. Photo: Author's own.

5.2 Free access systems

5.2.1 Case study: Mid-west dairies

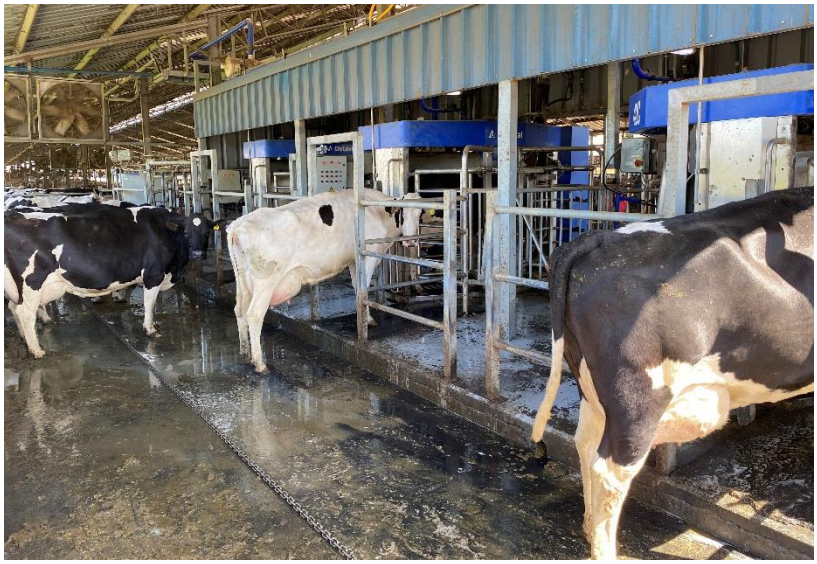
I visited two similar dairies in the Mid-west of the USA that had used a free access system to expand their dairy business. Both had installed between 30 and 40 robots to complement their 2,000 cow dairies being milked through a conventional rotary parlour. The farms reported large reductions in replacement rate when compared to their other facilities, however the robot barns were of far superior design. Running robots alongside conventional facilities had several advantages for the businesses. Cows that were non-compliant with the robots, for example those with slow milk speed or requiring to be 'fetched', could be sent back to the conventional dairy. Cows that were on antibiotics were retained within the conventional dairy as well, to allow maximum efficiency of the robots, thereby obviating the need to run a cleaning cycle after milking any antibiotic cow. When asked about their decision to use a free access system, the farms pointed to superior dealer support in their area and the uncomplicated installation of the system.

5.3 Guided and semi guided systems

5.3.1 Case study: Ancali Farms

Agricola Ancali is located near Los Angeles, Chile. Part of a wider agricultural company, the dairy milks around 5,100 cows through 86 robots. With yields of around 47kg and around 3,500g of combined fat and protein per cow per day, their productive performance is truly world class. The dairy initially opened with four internal rotary parlours, however since 2016 these have all been phased out over time, in favour of robots. As this was a retrofit and not a greenfield build, Ancali had to think about how the robots would fit in with the layout of the farm as it was. The freestalls were designed in a head-to-head format, where two rows of cows face each other. This made a true

guided system difficult to implement. Therefore, a compromise was made by utilising a system known as semi-guided cow traffic. After exiting the milking robot and gaining access to the feed fence, cows still have access to a bed but not water. Here the use of water alone is the driving force behind moving the cows around the system rather than water and a freestall.



Agricola Ancali robot barn (toll booth, semi guided system), Los Angeles Chile. Photo: Author's own.

5.3.2 Case study: Fair Oaks Farms

Fair Oaks Farms are a group of 10 dairies and a visitor centre located in the west of Indiana, USA. Historically groups of 3,000 cows have been sited together and served by one large rotary milking parlour. Their latest venture however has 'employed' 12 robots to milk 840 cows under one roof, with a viewing gallery and visitor experience situated above. The design involved three rows of freestalls served by one feed fence. To make a true guided system work, they have added an extra passageway as seen below.

Fair Oaks Farms robotic barn utilising a guided traffic system, Indiana USA. Photo: Author's own.

Fair Oaks Farms robotic barn showing milking and segregation area (in line, guided system), Indiana USA. Photo: Author's own.

5.3.3 Robot placement within guided and semi guided systems.

Within the guided system there exists several ways to position the robots after the cow gains access. The two most popular that I saw appeared to be 1) the toll booth system, where robots are laid out like cashiers at a supermarket checkout, and 2) the in-line system.

The toll booth system was generally accepted to be the most efficient in terms of cow throughput but resulted in having numerous robot rooms with only 2 robots in each, which can impact on their ability to be easily serviced and maintained. The in-line system meant that multiple robots could use one robot room, however cows both pre and post milking were mixed, and this can impact throughput due to some cows trying to pass through the robots' multiple times without exiting the area.

5.4 Group Management

Most larger herds ran all robot pens to a similar average number of days in milk, this resulted in maximum efficiency of all robots on the farm. As cows generally reach peak milk production at around 90 days and tail off significantly after 200, having this cross section of cows on each robot allows them all to work to their optimum efficiency. The exception to this however was the use of a separate first lactation animal pen. This appeared to result in less social conflict and bullying for these animals and reduced their wait time at the milking robot. Herds that I saw in Germany had installed a shell of a robot in the pre fresh heifer pen for use as an out of parlour feeder. This worked well to teach the animals how to enter and exit the robot. These farms reported it increased the number of robot visits in the first 100 days for first lactation heifers.

5.5 Batch Milking

A third but far less common method for designing box stall robot facilities exists, known as batch milking, was only seen once during my travels. It involves laying the robots out in a line or near each

other and herding the cows to the robots, a set number of times per day. This resulted in them being run in much the same way as a conventional milking parlour but without the labour requirements.

Summary

- Significant differences exist in philosophy of how to milk cows robotically.
- Guided or semi-guided traffic can result in lower fetch rates and lower pellet requirement.
- Free access system promoters often point to the fact that the cow is not restricted in any way and is allowed to do as she pleases.
- If possible, there appears to be merits to grouping first lactation animals together.

Chapter 6 - Repair and Maintenance

6.1 Depreciation

The rate of depreciation of box stall robots was cited to me by farmers as a reason for more of them not being sold. Surprisingly though, there is an extraordinarily strong second-hand market for robots. Most farmers that I have spoken to in the US are depreciating their robots over a period of 7-10 years but expect them to still be worth up to 40% of original resale value after that time. There were numerous examples of robots lasting well beyond that 10-year period, with some still functioning well approaching 20 years old. Lease finance also is gaining popularity, where the purchaser effectively pays a rental to use the equipment rather than buying outright. Longevity of the equipment is directly correlated to repair and maintenance which is discussed in the next section.

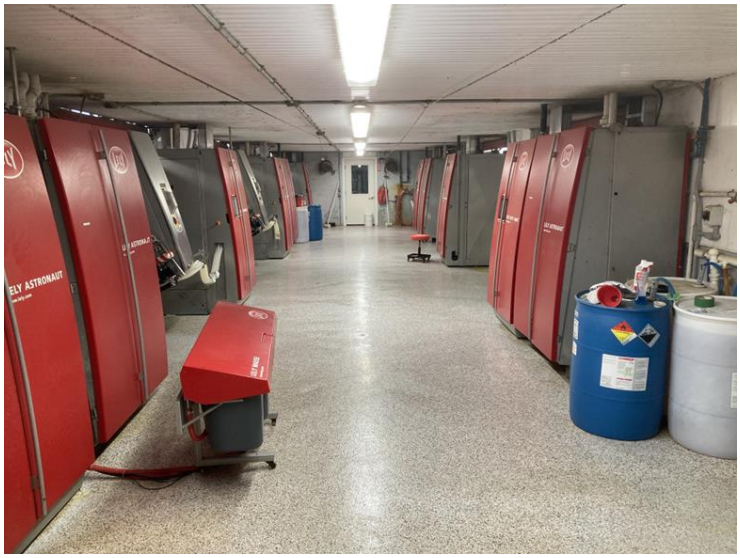
6.2 Maintenance and repair costs

Maintenance and repair costs were a topic that came up multiple times on my travels. Many people I have talked to in the UK often cite prohibitive costs as the reason for not using robotics on their own farms. The take home message I took from my time abroad was that if you keep robots clean and regularly serviced, then they will provide the farm with little hassle. Unlike conventional milking parlours where the tendency seems to be to run something until it breaks, robots require a strict servicing schedule to be adhered too. Any unnecessary down time is detrimental to its overall output. Keeping sensors and lasers clean and the robots in a general good state of upkeep ensured that they worked optimally for as long as possible.

A major advantage of larger farms is that they can do a large amount of the maintenance work in house. After reaching around 15 robots plus, most farms appear to be looking into employing their own technician, after the lapsing of the warranty period. A large amount of the cost associated with the repair and maintenance is not actually the parts but the labour cost, levied by the dealers. Many of the progressive dealers appear to be happy for on farm maintenance to occur, allowing them to focus their attention on further sales. One large farm in the US who have been running 40 robots for almost 10 years commented that their repair costs have gone down every year in that time. They put this down to the fact that their own herds' people and servicing team have simply got increasingly adept at fixing and repairing the robots in house.

6.2.1 Case Study: Hoenhorst Farms

Hoenhorst Farms in Ontario Canada is run by Cox Wensink and her very capable team. They are currently utilising 10 Lely robots across two sites. The cleanliness of the robot room was very impressive along with having an exceptionally low out of hours call out rate from the robots. Cox attributed the reason for this latter point partly to the way they rota their robot night check duty. Whoever is on duty for call out that night, oversees robot maintenance throughout the day. So effectively if they are called out for something that should have or could have been rectified during the day, then that is their own fault! Cox noted that this system worked well for the team, and they all took pride in the upkeep of the robots.



Robot room at Hoenhorst Farms, Ontario Canada. Photo: Author's own.

Decorated Lely Red Cow, Estela Farm, Trenque Lauquen, Argentina. Photo: Author's own.

Longs Peak Dairy robot room, Denver Colorado. Photo: Author's own.

Summary

- Servicing must be kept up to date to avoid unnecessary down time.
- Cleanliness is key to keeping robots functional and running well.
- Larger farms can take maintenance and servicing in-house to reduce costs.
- Having the whole team on-board when it comes to maintenance pays dividends.

Chapter 7 - Other Robotic Technology

7.1 Robotic rotary parlours

In New York State I managed to visit a dairy milking 2,800 cows through a fully robotic rotary parlour. Cows were brought to the parlour in the conventional way three times per day and the parlour prepped, milked, and post-disinfected on its own. The major concerns around the technology appeared to be the running costs and the initial capital cost. At the time, the technology was costing around £40,000 per stall. This resulted in a typical 72 stall rotary costing close to £2.9 million.

Robotic rotary parlour, New York USA. Photo: Author's own.

7.2 Robotic arms for rotaries

Various automated post spraying was being used on all the conventional rotary parlours that I visited on my travels. The technology ranged from in deck sprayers through to static timed sprayers and to teat spray robots. Teat spray robots were by far the most accurate. MVP dairy in Celina Ohio was one such dairy that I visited, they were using a Delaval teat spray robot and noted that it was saving them around 21-man hours per day. The fixed capital cost of this equipment meant that the larger the dairy was and the more hours the equipment was run for, then the faster the payback was on the investment.

7.3 Feed pushing robots

Many of the dairies that I visited have invested in feed pushing robots. Several manufacturers now make robots capable of pushing feed back towards the feed fence at a rate of around 30 ft per minute. The consensus amongst larger dairies was that this rate was too slow and as a result required a large number of push robots to get around all the necessary areas. The most intriguing product I came across was one by Rovibec Quebec which could push feed up at a rate of 100 ft per min, which was fast enough to cope with a 3,000-cow dairy.

7.4 Manure handling robots

Manure handling robots were seen on some of the farms I visited, mainly in Germany and the Netherlands. They cost around £30,000 at the time of writing this report and could handle manure from around 100 cows. The bigger dairies felt that this cost was not justifiable and most farms in the

US had opted to use conventional barn scrapers or a flood wash system. The flood wash systems worked very well. A major concern of many larger dairies was the machines' ability to manage sand laden manure. Sand is a common bedding choice in these dairies and contributes significantly to the decreased lifespan of such robots.

Manure collecting robots, Dresden Germany. Photo: Author's own.

Summary

- Robotic arms fitted to conventional rotaries are far more popular than fully robotic rotary parlours.
- Other robotic technology such as feed pushers and manure handling robots are becoming more present on farm, but their cost is a barrier to their use by some farms.

Chapter 8 - Other learnings from my travels

Although the focus of my study tour was robotics, it didn't stop me from advancing my learning around dairying and agriculture in general. This section highlights a few of those learnings.

8.1 Labour retention

With the focus of my scholarship being around robotics replacing labour, it may seem strange to talk about labour retention. However, we are a long way from the point where no labour is required on a large dairy farm and businesses need to learn how to attract and, more importantly, how to retain labour. One such agri-business that does a great job of both is Holsum Dairies in Wisconsin. Former manager and now retired Kenn Buelow has put staff welfare and fairness at the heart of their dairy operation. Simple schemes such as running an on-farm loan system for when staff are short of cash, and their large contributions to staff pensions have resulted in the business having an incredibly low staff turn over in an industry that can routinely see a 30% turnover rate of labour. Other corporate dairies within Wisconsin have picked up on the idea of investing in staff. Milksource LLC spend an enormous amount of money on staff training and development, with awards ceremonies routinely held on farm honouring long service to the business.

8.2 Water scarcity

The issue of water security reared its head several times whilst on my travels. Living in the Southwest of Scotland means that this is a topic that I am sheltered from in everyday life! Two examples really hit home of how much of an issue water scarcity is globally.

The first was in the Southwest of Kansas on a soon to be 20,000 cow dairy. Water extraction rights are tied to the farm and once the allotted amount has been drawn the farm has to stop pumping. However, a loophole exists where a business can purchase another farm hundreds of miles away and move the water rights to the current dairy setup. This struck me as incredibly unsustainable however it was commonplace in the US Southwest.

The second was not on a dairy farm but on an avocado and lemon plantation in central Chile. Water availability in Chile is a diverse issue, with the far South of the country having a plentiful supply but the middle and North lacking greatly. Avocados must be grown in the middle as they cannot be subjected to freezing conditions, however they are a water hungry crop. One farm I visited was feeling the effects of this water shortage massively. They owned 500ha of which only 40ha was being farmed. The day that I was there they had just turned off the irrigation for 10ha of lemon trees as they no longer had the water to sustain them. Their water permit allowed them to extract 80 litres per second however, even with all their pumps running, they were only managing 4 litres per second.

Dairying is an area of agriculture that is water hungry as well. Going forward the industry needs to get a handle on this and ensure that milk is being produced as sustainably as possible.

8.3 The power of people

My travels introduced me to so many interesting people and diverse cultures. It was amazing how meeting someone who has no interest in your subject can put you in touch with some of the best

contacts of the entire trip. I am now a major believer in taking information from every visit and person that I meet. The saying “if you didn’t learn anything then you didn’t ask the right questions” is a mantra I am going to follow from now on.

Chapter 9 - Discussion

Labour was a problem in every country I visited. From a reduction in Latin American labour availability in the USA, to the problems of labour efficiency in South America. What was clear was that robots save labour on a large herd model.

Historically the argument has been that labour is not saved but simply repurposed to somewhere else on the farm, post robot installation. Whilst this may be the case on smaller farms, large dairies were replacing milking labour with the robots, and this was backed up by the figures. One dairy I visited in Colorado was milking 4,200 cows through 60 robots and employed 25 full time equivalent labour units. A farm of this size working with a conventional milking system would require a staffing size of around 42. An interesting thing to note is that when doing cost benefit analysis of robots, labour inflation must be accounted for. For example, if the robots are being paid off over a 10-year period, then the labour saving should be calculated as an average of those 10 years. A salary today of £30,000 is the equivalent to almost £49,000 in ten 10 years' time, considering a 5% level of compound inflation.

Although cattle health is a bi-product of good management and barn layout and not simply milking system choice, I could not help but be impressed with how relaxed these large robot barns were. The animals in these barns were more than comfortable around strangers entering their facility. Staff also appeared more relaxed, with no shouting or loud noise evident at any of the farms that were visited. Cows were not herded three times a day into a collecting yard prior to milking and they did not stand for up to three hours per day waiting to be milked. Lameness levels were better than most conventional systems and all farms visited reported a reduction in replacement rate after the installation of robots.

After visiting many different barn layouts around the world, it became clear to me that a 'milk first' guided traffic system was the most effective one, especially for a large herd.

Some of these dairies have managed to decrease their in-robot pellet usage to around a kilogram per cow per day, with ambitions to go further. Many of the free access farms I visited were feeding up to 10 kilograms. The issue with this is twofold. Firstly, pelletised feed is expensive when compared to a blend as part of a total mixed ration. Secondly, this surge feeding of concentrate may result in ruminal acidosis. Although no trial work has been conducted to prove this, the University of Minnesota's Jim Salfer points to this as being a real possibility.

Dairies implementing guided traffic systems also tended to have lower rates of fetch cows (the percentage of the herd that must be brought by farm staff to the robot each day). This is largely because in a free access system there is nothing driving the cows to the robot. They can get all the feed they require at the feed fence and do not necessarily require the pellet that the robot is offering.

The final interesting point about guided traffic systems is that they are set up with a higher number of cows per robot and average a lower number of milkings per cow per day. These systems save some time by not identifying milking permission status within the box but by using the smart gate beforehand. What became clear was that these guided systems were milking the right cows at the

right time and farmers should not be concerned with average numbers of milkings per day. This highlighted to me they focus their efforts on getting fresh and early lactation cows to the robot for their maximum number of permissible visits, even if it results in late lactation visits tailing off significantly.

When thinking about purchasing robots, farmers and advisors should look at the return on investment, as if they were constructing a greenfield site. If the dairy already has a functional milking facility that is not at the end of its lifespan, then robots can look like a costly option. If, however, the farm must invest in some sort of milking equipment, then the robot versus conventional parlour costings can be fairly explored.

Batch milking systems appear to have limited benefits over conventional milking facilities other than a slight reduction in labour. They only have a slightly lower capital cost than a guided or free access robotic system and do not offer any of the benefits of increased milk yield or a reduction in replacement rate. Cows continue to be fetched to the parlour a fixed number of times and are exposed to the effects of bunching in collecting yards. The only logical situation I can see that would suit this sort of system would be a research facility. It would allow them to gain all the information from the robot and reduce labour whilst maintaining a structured milking regime.

Likewise, robotic rotary parlours seem to offer limited advantages over conventional rotaries other than a slight decrease in labour costs. There seems to be little development in this area now and, with the development of efficient robotic arms for pre and post milking duties, a more efficient option is to use these on a conventional rotary platform.

Other robotic technologies are gaining a larger following e.g. manure handling. However their cost and ability to manage sand laden manure is a potential obstacle for larger producers. For example, manure collecting robots offer one major saving, labour, although there is arguably a health benefit, it is difficult to quantify presently.

Chapter 10 - Conclusions

1. Robots are a profitable option for larger herds due to a reduction in replacement rate, reduction in labour but most importantly due to an increase in milk volume.

2. In my opinion guided traffic systems are the most cost-efficient option.

3. Maintenance and cleanliness are key to extending the lifespan of robots on farm.

Chapter 11 - Recommendations

Dairy Farmers

Robots are here to stay, and farmers should be designing new barns and facilities with robots in mind even if they do not plan on utilising them initially.

Farmers need to lose the obsession of chasing number of milkings per cow per day. Averages are not a good indicator of performance; it's more important to milk the correct cow at the right time.

Chapter 12 - After my study tour

Within my role as a dairy manager, I am looking more closely at the use of robotics in our own dairy and how they can help us move forward in the future.

Although it is an oft quoted cliché, the opportunity to carry out a Nuffield scholarship has really pushed me out of my comfort zone. In particular, when it comes to interacting with people outside my industry and with regards to public speaking. I really feel than my confidence in front of an audience has grown greatly.

I would like to use my experience to transfer knowledge and advice to other dairy farmers and industry representatives. I look forward to continuing my involvement within the Nuffield arena and encouraging a future generation into dairy farming.

Chapter 13 - Acknowledgements and thanks

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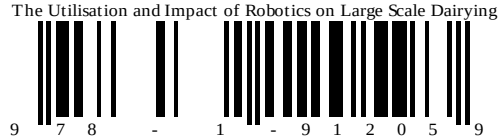
The Utilisation and Impact of Robotics on Large Scale Dairying



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