Labor Practices and Technology Adoption on New Zealand Dairy Farms

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Abstract:

Milk harvesting practices in New Zealand have changed substantially over time in response to increasing herd sizes and demand for more efficient systems. Observations on 10 farms, representing a range of herd sizes and milking facilities, indicated that of the time required for milking 17% was spent on preparation (fetching cows and setting the parlor up), 61% on milking (attaching and removing teat cups, maintaining cow flow, attending to udder health and equipment) and 22% of the time on post milking clean-up activities (including shutting cows away). Cows milked per hour ranged from 93 to 217 (calculated using all labor hours and excluding preparation and post-milking clean-up). Time per cow per milking ranged from 16 to 38s. Automating the cups on task within the current batch milking systems is often suggested as a means of dramatically improving milking efficiency. The observations showed that at present attaching teat cups accounts for 19-39% of time spent milking on New Zealand farms. Other activities such as fetching the herd, herd health and post-milking cleaning account for the bulk of the time required for milking. There is a need for technology to reduce the burden of a range of manual tasks in current milking practices including cup attachment, cup removal, health and milk quality monitoring, teat disinfection, animal identification and drafting. Many farms do not utilize existing technology which allows most of the in-parlor tasks (except cup attachment) to be automated. The need for automating the cup attachment task (in isolation from other milking tasks) during milking is greatest for the larger operations where farms are milking for extended hours with staff dedicated to the "cups on" task. On these farms the physical demands of cup attachment are contributing to problems with staff attraction and retention and in some cases causing physical repetitive strain injury. It is clear many dairy farms could improve their efficiency of operation through the adoption and correct use of existing automating technologies (e.g. automatic cup removers, drafting, teat disinfection and the use of electronic identification systems). It is suggested this is the next step required to lift the labor efficiency on farms. Once this has been achieved, further automation such as cup attachment within the batch milking systems can be considered.

Keywords. Labor requirements, technology adoption, automatic cup attachment.

Introduction

Milk harvesting is a task that has shaped dairy systems and the way of life on New Zealand dairy farms. From hand-milking to the sophisticated milking systems available now, dairy farmers, researchers and milking technology companies have sought continual improvement driven by the need for greater efficiency and throughput. However, despite these changes, unlike many off-farm processing systems, the milking operation is still reliant on substantial human input. This paper describes the historical development of milk harvesting technology on New Zealand dairy farms, quantifies current practices and considers the potential of automatic cup attachment technology for current diary designs.

The advent of machine milking in early 1900s heralded a major breakthrough in world dairying. New Zealand and Australia were early adopters of machine milking technology and historic data indicate more than 55% of herds were machine milked by the 1940s, (Janson, 1973). This compared favorably with

other developed dairying nations which were relatively slow to adopt the technology (Table 1). It is likely the uptake of machine milking in Australasia was predominately driven by the larger average herd sizes.

TABLE 1. The global use of milking machines at the beginning of the 1940s (Janson, 1973)

Country	% Herds machine milked	Country	% Herds machine milked
New Zealand	55	Denmark	10
Australia	55	Netherlands	3
Sweden	35	Belgium	2
UK	30	France	0.2
USA	10	Germany	0.2

Prior to 1960, the most popular parlor design in New Zealand was the walk-through or abreast parlor. The cows moved through the parlor individually, were milked side by side, with the operator moving between the cows on demand. The milking throughput from a walk-through parlor varied in the range of 4 -16 cows per bail per hour (bail = milking stall) with typically around 30 cows milked per labor unit per hour (Woolford, 1990). As the average herd size increased, and with little opportunity for milking efficiency gains within the existing infrastructure, the walk through parlors came under pressure. In response herringbone parlors first appeared in New Zealand in the late 1950s. They rapidly became accepted as ideally suited to the larger farming operations and allowed for more efficient labor utilization. It was also felt the herringbone provided better working conditions for the operator. While throughput measured in cows/bail was similar to the walk-through design, double-sided herringbones allowed cows to be milked in batches and it was common to see throughputs in the range of 100 cows/operator/hour.

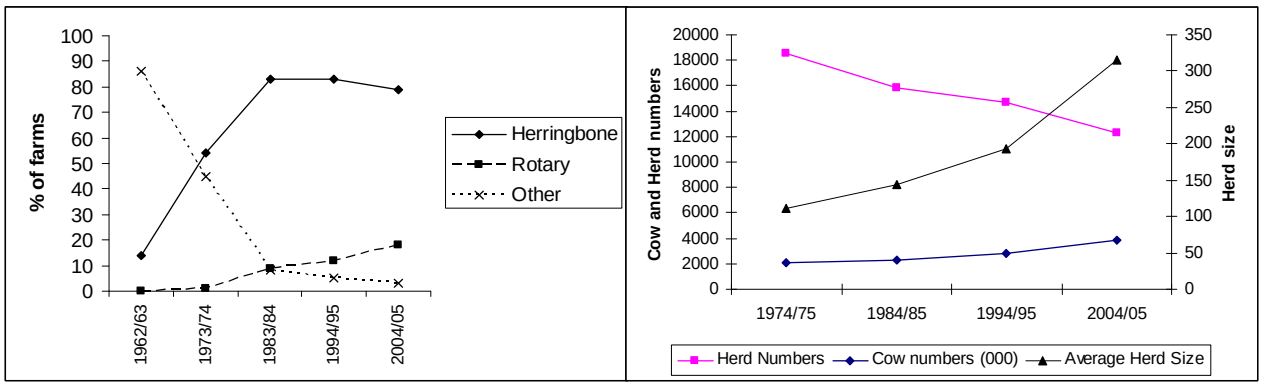

Figure 1. Distribution (%) of Milking Parlour Types in New Zealand (1973 to 2005) and Total cow and herd numbers and herd size in New Zealand, 1974 to 2005 (Woolford, 1990; NZDB, 1984; LICS, 2005)

A survey carried out by the New Zealand Dairy Board in 1963 found approximately 14% of parlors were of a herringbone type (NZDB, 1984). The survey suggested the average saving in labor for milking, after converting from a walk through parlor to a herringbone parlor, was 3.5 man-hours/day despite the fact herd size was often increased at the same time. A similar survey conducted in 1973 indicated the proportion of herringbone parlor had increased to 54% (NZDB, 1984). Further parlor design changes occurred around 1970 with the emergence of the rotary abreast parlor and the rotary herringbone parlors.

The national average herd size continues to increase (Figure 1) and there has been a steady shift in the type of parlor installed (LICS, 2005). A rapid uptake of herringbones occurred between 1973 and 1984 and the herringbone continues to be the most popular type of milking system in New Zealand. However, herd size has a major influence on choice of parlor type with larger herds having a relatively higher percentage of rotaries than smaller herds (Table 2).

TABLE 2. Distribution (%) of parlor type by herd size in New Zealand (NZDB, 1984)

Herd Size(Cows)	<100	100 - 199	200 - 299	300 - 399	>400
Herringbone	67	88	82	6	53
Rotary	3	7	17	31	40
Walk through	25	3	1	0	0
Other	5	2	0	3	7

Although, at a farm level, the uptake of rotary parlors has been less spectacular than the uptake of herringbone parlors through the 1970s, when the percentage of New Zealand cows milked with different parlor types is considered, the role of the rotary parlor in current New Zealand milk harvesting becomes clear with a doubling of the percentage of the national herd being milked in rotary milking parlors.

TABLE 3. Percentage of cows milked by different parlor types (LICS, 2005)

Year / Parlor Type	1995 (%)	2005 (%)
Unknown	1	2
Herringbone	80	63
Rotary	18	34
Other	1	1

Further evidence that rotary parlors are being installed more commonly on farms larger than average size can be seen from the most recent data from Livestock Improvement Corporation (Table 3). The average size of herds milked in herringbone and rotary parlors was 196 and 228, respectively, in 1995 and increased to 289 (32% increase) and 537 (57% increase), respectively in 2005. There is a clear trend within the New Zealand dairy industry for herd expansion and with this trend data suggest the percentage of cows milked in rotary parlors will continue to increase.

Automation

Milking remains a significant and time-consuming task on farms. Once a point is reached that the number of milking units is no longer the barrier to improved throughput, further improvement can only be achieved by removing elements of the operator work routine from the milking process. Consequently, there has been a drive to make the job more efficient and less physically demanding through the use of automation. If all the tasks associated with the successful milking of one animal take 30 seconds, then the

maximum number of animals an hour the operator can milk is 120 cows. This is illustrated in Table 4. Unless progress can be made to reduce the time associated with elements of the work routine, there is little potential gain in efficiency in installing larger parlors with more milking units. Further gains in productivity need to be obtained either by examining the milking routine or substituting labor with automation

TABLE 4. Effect of work routine on parlor throughput

Element	Time/cow (s)
Fetching cows	6
Cup attachment	10
Cup removal	3
Teat disinfection	2
Cows out	4
Miscellaneous	5
Total	30
Cows / hour	120

Automatic Cup Removal

Simple automatic cup removal devices (ACR) have been available in New Zealand since the late 1970s. These devices monitor the milk flow rate from individual cows and at a threshold the milking vacuum is shut off and a ram is activated to withdraw the cups from the cow. The adoption of ACR in New Zealand has traditionally been low. This is explained in part by the perception the only benefit of ACR in a batch milking scenario in the predominant herringbone parlor configuration is to minimize over milking. However, when ACR are installed in a rotary configuration, particularly the abreast design with the operators standing on the outside of the platform, there is an opportunity to substitute ACR for a labor unit.

Automatic Teat Disinfection Systems

Post milking teat disinfection is an established component of many mastitis control strategies. This is normally performed manually in New Zealand using either a pressure operated spray lance or more rarely a dip cup. Automating teat disinfection (in addition to fitting ACR) can save a single labor unit. Installing an exit race sprayer for herringbone configurations may not lead to a reduction in labor but free time for the operator to handle more milking units and therefore improve productivity. Automated teat disinfection systems have been available in New Zealand for more than 20 years.

Automatic Drafting

Removing the labor requirement to separate animals after milking can have a significant impact on the performance of the milking operation. When an operator is involved with animal separation, other tasks are not being done and performance suffers. With larger herds identification and drafting of individuals are major tasks. Automatic drafting is not routinely installed on New Zealand dairy farms.

Cup Attachment and the Development of Automatic Milking Systems (AMS)

Internationally, the need to reduce total labor associated with harvesting milk has led to the development of Automatic Milking Systems (AMS). Work on fully automating the milking process started in the 1950s. From 1970-1990 a number of research institutes in Europe were working on techniques for locating teats and attaching teat cups automatically as an integral component of an automatic milking system. The first experimental AMS appeared in 1984 and commercially on farms in the Netherlands in 1992. The number of units installed, from a variety of different manufacturers, rose steadily through the late 1990s. By 2004 AMS was in use on more than 2500 farms in more than 20 different countries around the world (Figure 2). Currently all AMS are designed to use 24 hour milking and are either single stalls (one robotic arm per stall) or multi-box systems (up to 5 boxes serviced with one robotic arm). All attach the teat cups from the side of the cow. Unlike the uptake of milking machines, the uptake of AMS in New Zealand has been very slow. The first New Zealand AMS unit was installed on a research farm in 2001 (Jago, et al., 2002) and as yet there are no commercial installations.

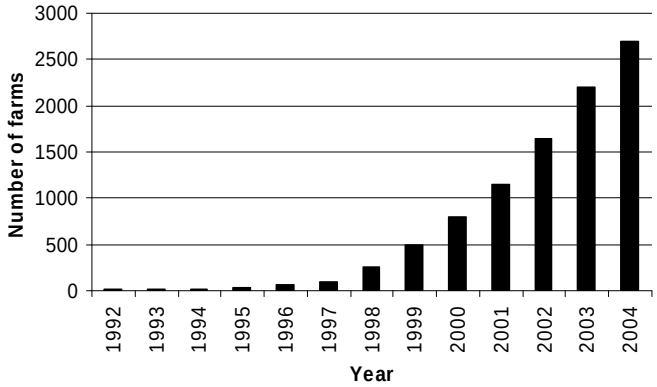

Figure 2. Number of commercial farms world-wide harvesting milk with automatic milking systems (De Koning, 2004, updated for 2004 by M. dam Rasmussen).

Quantifying Current Milk Harvesting Practices

Observations of milking labor practices were carried out on ten farms, across a range of systems, described in Table 5. A total of four milkings (two am and two pm) were observed on each of the 10 farms. The observers recorded and timed all of the activities of the people involved in milking beginning at the time someone went to collect the cows through until the cows were shut away after milking and the parlor was cleaned up. All the observations were carried out during late January through to early March 2006 when cows were in mid/late lactation.

TABLE 5. Description of parlor type and size and herd size on the observation farms

Farm number	Milking Parlor type	No. bails	No. cows
1	Small Herringbone	14	122
2	Small Herringbone	18	173
3	Large Herringbone	36	553
4	Large Herringbone	30	404

5	Small Rotary	22	188
6	Small Rotary	17	153
7	Small Rotary	24	468
8	Large Rotary	60	653
9	Large Rotary	50	545
10	Large Rotary	50	767

Milking labor was divided into three major task groups:

1. Preparation - including fetching cows and setting the parlor up.
2. Milk harvesting – including attaching and removing cups, activities associated with getting cows on and off the platform or row, teat disinfection, washing floors between cows, fixing equipment such as hoses, detecting unwell cows or abnormal milk and attending to health cows.
3. Post-milking clean-up – including cleaning the plant and yard, and shutting the cows away.

Data from each farm for each of these three major groups of activities, as well some sub group activities such as attaching cups, are presented in Table 6. The time is an average for the two days and gives the total amount of time spent (including all staff) each day on all activities associated with milking (e.g. 2 people spending 3 hours each milking equals 12 hours total time to harvest that farms milk).

For the smaller herds (less than 200 cows) milked in small parlors the total time (morning and afternoon milkings, including all labor) required for milking ranged from 3:43 to 4:52 (hour:minutes). Farm 7 was milking a large herd through a small rotary and consequently had a longer milking time (6:20). On the other larger farms total milking time varied considerably, ranged from 9:15 to 16:49. It is interesting to see where the time was spent across the different activities involved in the milking operation. The average (range) across all the farms was:

- Preparation 17% (11-21%)
- Milk Harvesting 61% (55-65%)
- Post-milking Clean-up 22% (15–29%)

There is considerable range within each of these activities (Tables 6 and 7) with 11-21% of time spent in preparation, mostly collecting the cows, and a range in teat cup attachment from 19% to 39% of the total labor requirement. A similar amount of time (21-43%) was spent with other activities such as taking cups off, teat disinfection, fixing equipment, maintaining cow flow and washing. The remaining 15-29% of time was spent cleaning up after the cows had been milked. There did not appear to be major differences between parlor types and herd sizes.

TABLE 6. Time (hr:min) spent on each activity in a 24 h period (morning and afternoon milkings) for 10 New Zealand Dairy Farms.

Activity	Small Herringbone		Large Herringbone		Small rotary			Large rotary		
Preparation (set- up,	1:02	0:29	3:02	1:52	0:31	0:50	1:07	2:37	2:22	2:11

getting cows)										
Attaching Teatcups[1]	1:08	1:10	3:42	2:33	1:45	0:58	2:23	3:22	2:09	4:21
Teatcup removal	-	-	-	-	-	0:47	-	2:24	0:07	-
Teat disinfection	0:14	0:10	0:50	0:34	-	-	-	-	0:55	-
Health herd	-	-	0:50	0:06	-	0:04	0:29	1:55	0:41	1:14
Other[2]	1:13	1:00	5:20	2:47	0:56	0:51	1:14	2:30	2:57	1:28
Clean up and put cows away	1:19	0:53	3:11	1:25	1:23	1:12	1:09	3:09	2:28	2:32
Total	4:52	3:43	16:49	9:15	4:31	4:41	6:20	15:56	11:29	11:28

[1] I*ncludes maintaining cow flow, fixing equipment, hosing during milking, putting cups back on, putting chains up.*

[2] *Includes taking cups off one cow and putting them on for Herringbone parlors*

TABLE 7. Percentage of the milking operation spent on the major tasks for each farm.

	Small Herringbone		Large Herringbone		Small rotary			Large rotary		
Farm Number	1	2	3	4	5	6	7	8	9	10
Activity	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	%)
Preparation	21	13	18	20	11	17	19	18	20	16
Milking - cupping	26	32	22	28	39	20	36	37	19	21
Milking – other activities	29	32	42	37	21	37	27	23	40	43
Clean up	24	23	18	15	29	26	18	22	21	20

<u>Measures of milking efficiency</u>

There are many ways to measure efficiency in the milking operation. The measures used depend on what is important to the individual farmer or researcher. The time spent per cow per milking includes only the time from first cups on to last cups off and is illustrated in Figure 3. Similar information is presented in Figure 4, but includes the preparation and post-milking clean up activities in the calculation.

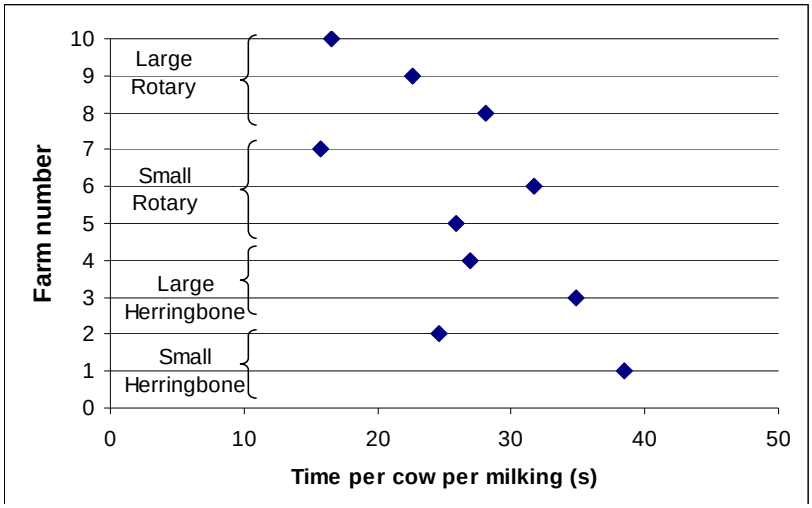

Figure 3. Time per cow per milking when using only the time from first cups on until last cups off (i.e. excluding parlor preparation and post-milking tasks).

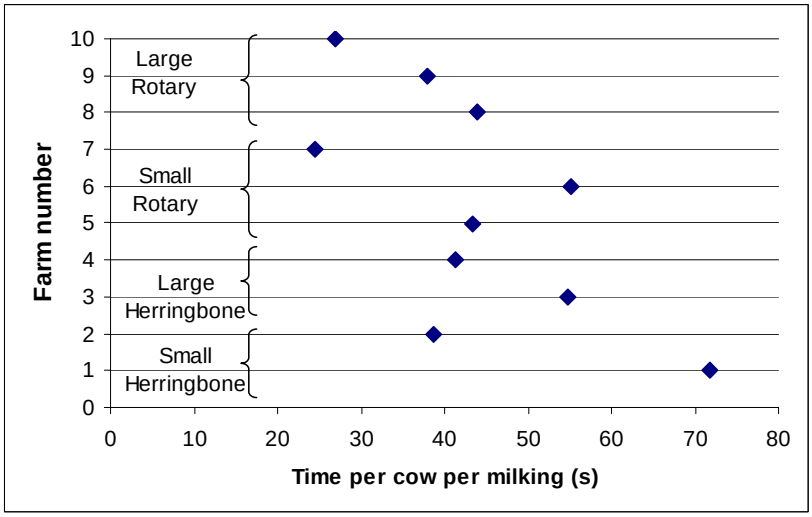

Figure 4. Time per cow per milking (including parlor preparation and post-milking tasks).

Another measure of efficiency is milk harvested per hour (Figure 5). The calculation has been made using the total time required to harvest the milk not just from cups on until cups off (i.e. includes parlor preparation and cleaning up time). There was once again a large range in harvest rates, from 316 to 1145 Liters/hour. Using this measure the larger rotaries tend to be more efficient.

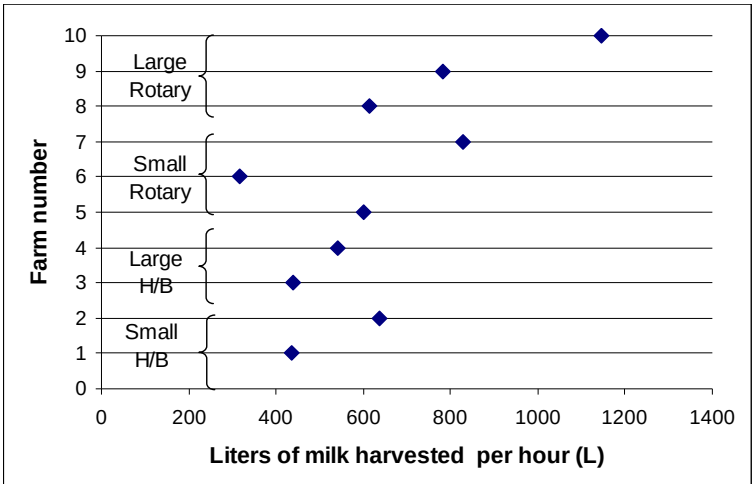

Figure 5. Liters of milk harvested per hour

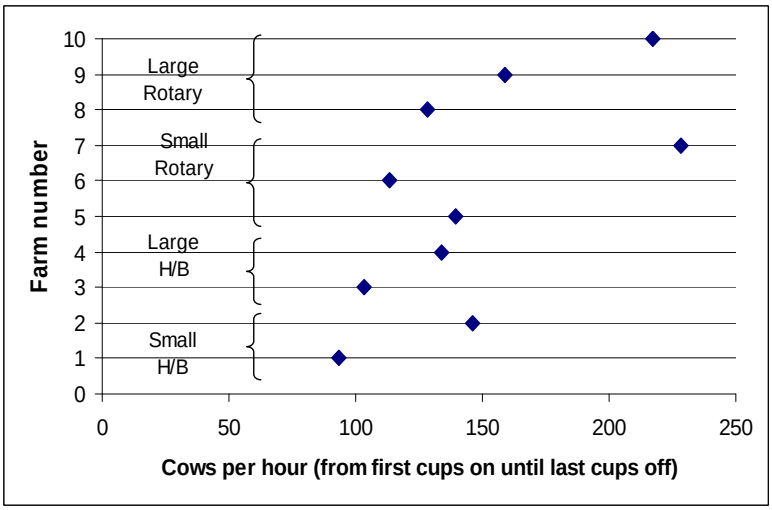

Figure 6. Cows milked per hour calculated using time from first cups on until last cups off.

There was almost a two-fold difference across the farms in the number of cows milked per hour (including all labor required from time the first cups went on until the last cups came off (Figure 6)). There is considerable variation in efficiency of milking across the study farms indicating potential for improvement through use of existing available technology and/or improved milking routines.

Farmer Views and Milking Systems Issues

In considering a new technology, such as automatic cup attachment, it is important to gain input from the people who would be most influenced by its development. Three focus groups of nominated members were held in the Waikato and Timaru regions during April and May 2006. The purpose of the workshops was to:

- Understand farmer views of general use of technology on farms
- Determine the issues with current milk harvesting operations
- Assess farmer expectations of automatic cup attachment technology

Effort was made to attract participants from a range of farm sizes. The ten farmers who took part in the time-in-motion milking studies (described above) were invited to attend. In all 22 people (18 male, 4 female) participated in the sessions, representing 19 farms. The majority were owner-operators, 30 to 50 years of age with medium to large farms (range 175 – 1200 cows) milking through rotary parlors.

It became clear through the workshop discussions that many available technologies were not in use. It was also clear that most participants were looking at making some changes to their milking operation in the next 5 years to improve overall performance. Participants had more difficulty identifying specific changes they would be making further ahead. Cow identification, drafting, heat detection and mastitis detection were tasks farmers considered would benefit from automation. Drafting, diverting milk, parlor capacity and mastitis detection were found to be very limiting in their current systems; while cup attachment, cup detachment, milk quality and plant washing were not limiting. Relative to other tasks, cup attachment was not considered a limiting factor. Most agreed to use highly skilled staff for this task, acknowledging that while cup attachment itself was a low skilled task, additional skilled tasks were performed during this operation. There was limited understanding of the concept of automating cup attachment and farmers generally had an unrealistic expectation of reliability and high expectations of speed of operation.

Assessment of Automatic Cup Attachment (ACA)

Field observations identified tasks farmers perform during milking and show clearly a significant proportion of time is consumed by tasks other than putting cups on cows. Each phase of the milking operation is important when targeting areas for efficiency gains. If there was a machine putting cups on, how fast would it have to operate to achieve equivalent performance to humans? On large rotaries attachment takes 9 seconds on average but it takes 22 seconds on a small rotary. The difference is due to the slower platform speed on the small rotary allowing the operator more time to attach the cups. Herringbone parlors showed more variation than rotaries with a range from 12 to 19 seconds (including time for taking the cups off from the previous cow and putting them on the next cow). To not increase overall milking time, ACA technology needs to achieve a cup attachment speed per cow of around 22 seconds for smaller farms and 9 seconds on the larger operations.

Milking technology suppliers based in Europe generally consider New Zealand to be a low-cost structure dairy industry with low uptake of existing technology. Their perception is the market for automatic cup attachment is limited. The view expressed by companies operating in New Zealand was somewhat different, based mainly on their local experience of the changing market. There is widespread agreement that any development of automatic cup attachment technology will not be to retrofit the technology into existing parlor designs. The most probable route will see a completely new design, which may involve approaching cup attachment from the side of the cow which will significantly slow throughput rates. Patent roadblocks are clearly significant for the local development of automatic cup attachment technology.

Whole-farm economic analysis was done for two levels of automation: A basic ACA system which places teat cups on an udder but carries out no teat preparation, mastitis or abnormal milk detection or milk diversion, and a comprehensive ACA system which carries out all of the duties of the cups on operator including identifying individual animals and diverting milk, attaching teat cups, detecting mastitis and abnormal milk, dealing with failed attachments, slow milking animals and machine cleaning. Details of this analysis are provided in Ohnstad and Jago (2007).

The economic model predicted ACA would increase the cost of milk production with both levels of technology for all farm sizes. The economic model also indicated automation of cup attachment with the other key tasks associated with milking cows is economically more attractive than automating the cup attachment task in isolation. Larger operations may become more sustainable as the manual chore of

attaching cups will have been removed but would likely have no positive impact on hours of work which will continue to be driven by the most common twice daily batch milking approach.

The skill level required to perform the remaining tasks in milk harvesting with ACA technology is important. The analysis assumed a fixed rate ($/hour cost) for all labor input, taking account of waged staff and management labor rates to arrive at an overall labor cost per hour. If a lower level of skill is required as a result of the automation, the labor savings (in dollar terms) may be greater, however if a higher level of skill is required to oversee the operation, labor savings will be reduced. The tasks remaining relate to animal health monitoring, trouble shooting and general oversight of operations which could be assumed to require a high level of skill. These results indicate uptake of ACA technology will likely be driven by the labor supply and sustainability of current practices rather than reduced costs of production.

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