DairyNZ Milksmart

Sizing a dairy to maximise milking efficiency

Dairies run most efficiently when the capacity of the equipment to milk the cows (cluster throughput) matches the capacity of the labour to milk the cows (milker throughput). This means people are not waiting for the equipment to finish and the equipment is being fully utilised, not idle and waiting for the milkers to catch up.

The following sections explain the steps needed in more detail:

Cluster throughput (cows/cluster/hour)

The number of cows that need to be milked an hour is one determinant of the number of clusters required in the dairy. It is influenced by two things:

- the time that a typical cluster is attached to each cow (the 'maximum milk out time'),
- and the time taken to remove the clusters from one cow and attach them to another (the 'cluster idle time').

Additionally:

- the maximum milk out time and the cluster idle time added together make up the 'unit time'.
- The cluster throughput is 60 minutes divided by the unit time.

Maximum milk out time

The maximum milk out time is the time a cow takes to be milked, and depends on the yield. As a preliminary guide, it is the time taken for the slowest cow in a batch in a herringbone or equivalent to the time between 'cups on' position to 'cups off' in a rotary.

For seasonally calving herds, and assuming the herd milking speed is determined by the slow-milking cows, a guideline to the maximum milk out times is shown in Table 1.

NB. If using Max T these figures will need to be recalculated.

Average cow yield per milking (litres)	Milk flow rate of slow milking cows (litres per minute)	Maximum milk out time (minutes)
10	1.7	6
15	1.8	8.3
20	2.2	9

Table 1. An estimate of milk out time in seasonally calving herds based on research at the National Milk Harvesting Centre, Australia.

Rotary dairies

The maximum milk out time is the critical determinant of the overall unit time when sizing rotary dairies and can be predicted using Table 1. The rotation speed is adjusted to ensure a set proportion of cows are milked out in the time it takes to travel between 'cups on' and 'cups off' positions - giving the milk out time.

The time taken to travel between the 'cups on' and 'cups off' positions must be adequate for most cows to be completely milked without significant over-milking of the others.

Sometimes the rotation speed is dictated by factors other than milk out time, such as the time required for the cows to eat their allocation of feed or the ability of the cupper. In this case the time required to eat the feed on the platform replaces the 'milk out time' component of the unit time.

Seasonal variation in milking out times

Peak milk production and lower milk production i.e. late stage lactation, need to be taken into account when sizing the dairy. Businesses with seasonal milking herds will need to consider the following:

- During peak production a milker can handle more clusters due to longer milk out times.
- During times of lower milk production, as in late lactation, milking out of each cow takes less time. The number of clusters that can be handled comfortably by one milker may limit any attempt to minimise the time it takes to milk a herd, i.e., unless additional labour can be used efficiently.

In New Zealand most farmers ignore this situation and expect better cow flow to compensate; generally in the heat of late summer it does not.

Consider the following steps:

Cluster throughput (cows/cluster/hour)

This is the number of cows that can be milked/hour with each cluster.

Cluster throughput = 60 minutes ÷ Unit time (minutes)

Unit time

Unit time = Maximum milk out time + Cluster idle time

Cluster idle time

This is the time taken for the cluster to be taken off one cow and attached to another.

In herringbone dairies cluster idle time varies between 10 and 15 seconds. In any double up system it is longer.

In rotary dairies cluster idle time is likely to be 1 to 1.5 minutes. It is the time taken for unattached clusters to travel the distance between 'cups off' and 'cups on'.

Herringbone example

Using a cluster idle time of 0.25 minutes (15 seconds) and cows giving 15 litres at a milking with a maximum milk out time of 8.3 minutes:

8.3 mins + 0.25 mins = 8.55 mins (unit time)

Rotary example

For a rotary dairy, unit time is equivalent to the time taken for one rotation of the platform.

If each rotation of rotary platform takes 10 minutes this is equivalent to a 10 minute unit time.

Herringbone example

60 minutes ÷ 8.55 minutes = 7 cows/cluster/hour

Using the above example with an 8.55 minute unit time, each cluster can milk out a maximum of 7 cows in one hour.

Rotary example

Using a 10 minute unit time, each cluster can milk 6 cows/hour.

60 minutes ÷ 10 minutes = 6 cows/cluster/hour

Milker throughput (cows/hour)

The second part of calculating the ideal number of clusters for a dairy is to determine how many cows milkers can milk in one hour (cows/hour). This can then be balanced with the equipment capacity (cows/cluster/hour). Calculating the work routine time is the first step in determining milker throughput.

Work routine time

The work routine time (WRT) is the time required to complete all the milking tasks for an individual cow.

Tasks in the work routine include cow entry, feeding, teat preparation, cluster attachment, cluster removal, teat disinfection, cow exit and other miscellaneous duties.

Any removal of work routine tasks, or using more efficient ways of doing the planned tasks will decrease the work routine time and increase the theoretical dairy size. For example, one expects cows to flow without intervention through well-designed herringbones or rotaries so that the cows' entry and exit time can be close to zero. Automation can avoid the need for time allocated for work input into feeding, cluster removal and manual teat disinfection.

Calculate how much time your work routine takes. What changes could be made to reduce the length of the work routine time?

Is it important to keep the option of spending a bit more time with some cows if they need it?

Herringbone example

A typical example of a work routine time from a herringbone dairy is given in Table 2.

Task	secs/cow
Cow entry (done while clusters are attached on other side)	3
Feeding	1
Teat preparation (done with attachment)	2
Cluster attachment	10
Cluster removal	5
Teat disinfection	3
Cow exit	3
Miscellaneous	3
Total work routine time	**30**

Table 2. Example of work routine time for an operator in a herringbone dairy.

Rotary example

In a rotary the cups-on and cups-off operators act independently. Example work routine times for a rotary dairy are shown in Table 3.

Task	'Cups on' secs/cow	'Cups off' secs/cow
Cow entry	0	0
Feeding	0	0
Teat preparation	2	0
Cluster attachment	8	0
Cluster removal		4
Teat disinfection		3
Cow exit		0
Miscellaneous	1	1
Total work routine time	11 secs	8 secs

Table 3. Example of work routine time for the 'cups-on' and 'cups off' operators in a rotary dairy.

As in this example, it is generally the 'cups-on' operator that is the busier. However in some larger rotary dairies where two milkers attach clusters, the operator removing the clusters and teat spraying can be the busiest (measurements of these operations on farms can often provide a guide to where there can be gains in milking efficiency).

Milker throughput

It is possible to estimate what the theoretical maximum milker throughput could be given an estimated work routine time. This is the number of cows, in theory, milkers could handle in an hour given their work routine times. In reality, their performance in practice is likely to be less than this theoretical maximum.

The overall milker throughput (cows/hour) of a dairy can be estimated using the following equation if the work routine time and number of operators are known.

Milker throughput (cows/hour) = 60 ÷ work routine time (secs) x 60 x number of operators

Herringbone example:

Using the previous example of a work routine time of 30 seconds, a single operator could handle 120 cows/hour.

e.g. 60 ÷ 30 secs x 60 x 1 = 120 cows/hour

Or, two milkers could handle 288 cows/hour

e.g. 60 ÷ 25 secs x 60 x 2 = 288 cows/hour

Work Routine Time (secs/cow)	1 operator	2 operators
15	240	480
20	180	360
25	144	288
30	120	240
35	102	204
40	90	180

Table 4. Estimated herringbone milker throughput (cows/operator/hour) based on work routine time.

Rotary example

With rotaries, it is the slower operator, cups-on or cups-off, that determines the theoretical milker throughput (cows/hour). The same simple equation from herringbone dairies is used for each work station.

To calculate the milker throughput of a rotary it is first necessary to calculate the number of cows that the ‘cups on’ and ‘cups off’ operators can handle independently at each work station.

Milker throughput ‘cups on’ (cows/hour) = 60 ÷ WRT x 60 x number of operators at ‘cups on’

Milker throughput ‘cups off’ (cows/hour) = 60 ÷ WRT x 60 x number of operators at ‘cups off’

For example:

A 10 second work routine time for a single ‘cups-on’ operator gives a maximum ‘cups on’ labour performance of 360 cows per hour (that is 60 ÷ 10 secs x 60 x 1 operator).

An 8 second work routine time for a ‘cups off’ operator gives a maximum ‘cups off’ labour performance of 450 cows/hour (that is 60 ÷ 8 secs x 60 x 1 operator).

In this example the ‘cups on’ operator limits the performance of both ‘cups on’ and ‘cups off’ work stations and so the overall labour output is limited to 360 cows/hour.

Work Routine Time (secs)	1 operator at a work station	2 operators at a work station
6	600	1200
8	450	900
10	360	720
12	300	600
15	240	480
18	200	400

Table 5. Estimated rotary milker throughput (cows/operator/hour) at each work station based on work routine time.

Sizing a herringbone (clusters/operator)

The optimum size (clusters/operator) for a herringbone dairy is a balance between the maximum possible cluster throughput (cows/cluster/hour) and milker throughput (cows/hour).

Once the unit time and the work routine time are known then the number of clusters that each operator can handle can be calculated. This is the last step in sizing a herringbone dairy.

Clusters per operator = unit time (minutes) x 60 ÷ work routine time (seconds)

For example, a single operator with a unit time of 8.25 minutes and a work routine time of 25 secs could theoretically handle 20 clusters.

e.g. 8.55 minutes x 60 ÷ 25 secs = 20 clusters per operator.

Unit Time (mins)	Work Routine Time					
	15 secs	20 secs	25 secs	30 secs	35 secs	40 secs
7	28	21	17	14	12	11
8	32	24	19	16	14	12
9	36	27	22	18	15	14
10	40	30	24	20	17	15
11	44	33	26	22	19	17
12	48	36	29	24	21	18
13	52	39	31	26	22	20
14	56	42	34	28	24	21

Table 6. Theoretical 'clusters per operator' values calculated from unit time and work routine time for herringbone dairies.

Doubling up on milking equipment

This can improve throughput by about 50% but with double the staffing needs, cleaning material and maintenance costs.

Sizing a rotary (number of clusters on platform)

The number of clusters in a rotary dairy is usually based on the rotation speed and the unit time - with the labour resources being allocated to match the workload.

Step 1. Rotation speed

The first step is to work out the rotation speed based on the number of cows that are required to be milked in an hour.

The rotation speed is usually expressed in seconds per bail. This is the time that it takes for 1 bail position to rotate past a certain point. The maximum theoretical throughput (cows/hour) of a rotary dairy is a function of the rotation speed of the rotary platform (Table 7).

Rotation speed = 3600 seconds/hour ÷ cows/hour

The cows/hour throughput figure used to calculate the rotation speed should take into consideration factors that limit the efficiency of bail use on each rotation. For example, cows which go round twice, empty bails, and stopping the platform. Australian research indicates that most rotary dairies operate at about 85% of their calculated maximum theoretical output.

Rotation speed (secs/bail)	**Bail use efficiency (%)**				
	100 (theoretical maximum)	**95**	**90**	**85**	**80**
7	514	489	463	437	411
8	450	428	405	383	360
9	400	380	360	340	320
10	360	342	324	306	288
11	327	311	295	278	262
12	300	285	270	255	240
13	277	263	249	235	222
14	257	244	231	219	206
15	240	228	216	204	192

Table 7. Theoretical outputs (cows/hour) calculated from rotation speed at 'steady state'.

The activity that takes the longest time limits the rotation speed of the rotary. The most rate limiting activities that must be undertaken on a rotary platform are (in order):

- The time it takes at the 'cups on' position to prepare teats and attach the cluster - a minimum of 8-9 seconds is required to do a careful job in a sustainable manner.
- The time it takes at the 'cups off' position to remove the clusters and disinfect teats - a minimum of 6 seconds is required to do a good job here.
- The time available for each cow to enter onto the platform - generally a minimum of 5-6 seconds although some large rotary dairies manage to load cows in little more than 4 seconds.

Automation or increasing the number of operators at the ‘cups on’ or ‘cups off’ positions allows for faster rotation speeds - sometimes rotation speeds are only limited by the time that it takes for a cow to load onto the platform.

Step 2. Number of clusters

The second step is to use the predicted unit time to calculate the number of clusters required on the platform.

Number of clusters = 60 x unit time (minutes) ÷ seconds per bail

The number of clusters required on the platform can be easily calculated from the expected unit time (time taken for one rotation of the platform) once the rotation speed per bail (and so the required cows/hour output) has been decided (Table 8).

Rotation speed (secs/bail)	Unit Time (minutes)					
	7	8	9	10	11	12
7	60	69	77	86	94	103
8	53	60	68	75	83	90
9	47	53	60	67	73	80
10	42	48	54	60	66	72
11	38	44	49	55	60	65
12	35	40	45	50	55	60
13	32	37	42	46	51	55
14	30	34	39	43	47	51
15	28	32	36	40	44	48

Table 8. Number of clusters required on a rotary platform calculated from the anticipated unit time and rotation speed.

Step 3. Check herd milking time

The last step is to check that the herd’s milking time from first cow in to last cow out is acceptable.

Herd milking time (minutes) = number of cows to be milked ÷ cows/hour output x 60 + unit time

For example:

A 600 cow herd with an output of 340 cows/hour (9 seconds per bail at 85% bail use efficiency) and a unit time of 10 minutes, would take 116 minutes from the first cow entering the platform until the last cow exits the platform (600 ÷ 340 x 60 + 10 = 116 minutes).

e.g. 600 cows ÷ 340 cows/hour x 60 + 10 minutes = 116 minutes.