FEEDLOT DESIGN AND CONSTRUCTION

35. Feed mixing and delivery

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Introduction

Thorough mixing of a ration provides a homogenous composition so that every animal receives the required intake of each ingredient. It may also assist palatability by helping to mask the flavour of less palatable ingredients.

Mixability may be affected by the feed commodities being used, mixing action, mixing time, mixing sequence and accuracy of adding each ingredient. Particle size may range from coarse grains and roughage to liquids and fine chemical particles.

The desired process is a well mixed ration in which individual feed ingredients have been accurately batched together by weight, uniformly mixed and then delivered to the cattle in a timely and efficient manner at a repeatable time of day.

The components of the feed mixing and delivery system are feed ingredient storage areas (see *Sections 30* to *34*), feed batching and mixing equipment and equipment to deliver the mixed feed to the pens.

Design objectives

The feed mixing and delivery system should be designed, constructed and maintained to ensure that

- The overall system will meet the requirements for mixing and/or delivery of the ration.
- Batching of feed ingredients is accurate and efficient.
- Spillage and wastage of ingredients is minimised.
- Ration is thoroughly mixed without damage to ingredients.
- Correct quantity of the appropriate feed is delivered to the cattle.
- The system and the equipment are efficient, safe and convenient to operate, even in adverse weather conditions.
- Equipment is maintained in good working condition.

A tractor drawn horizontal vertical screw mixer set up as a stationary unit.

Mandatory requirements

Feed delivery vehicles should be compliant with state regulations for use on public roads. This may mitigate against any claims of negligence in the event of an accident in the feedlot.

Design choices

Function of mixer

The mixer has to uniformly blend particles of different sizes, moisture content and bulk density into a ration. Samples taken from the beginning, middle, and end of unloading should show no significant differences in ration composition when the load is fed to all pens.

Over-mixing can be as detrimental as under-mixing in achieving optimum uniformity and trials need to be carried out with different ration formulations to find the optimum mixing time for each combination of ration ingredients.

Feed particles are moved mechanically with augers, reels, chains and drums. This may reduce the size of some particles, which can have a beneficial or detrimental effect.

Manufacturers produce feed mixers of varying designs and operational differences and the feedlot has to select a design that suits its feed ingredients, physical properties of the ration, feedlot capacity and method of feed delivery.

All the mixers on the market are batch mixers, in which feed ingredients are added one at a time until the required weight of each specific ingredient is reached and the batch is complete. The order of adding feeds can affect the mixing ability and/or time of mixing and this may depend on the type of mixer and its mixing action.

Mixers can be categorised into stationary or mobile mixers, with either horizontal or vertical mixing actions.

A tractor-drawn vertical mixer.

Vertical mixer

The vertical mixer consists of a large tub with one or more vertical screws centred in the tub. The screws elevate the ingredients to the top of the mixer, where they fall by gravity to the bottom to be mixed and re-elevated. The continuous lifting and falling action creates a blended mixture of ingredients. Knife sections may be attached to the screw flighting to cut material, such as hay or straw. Movable shear or restrictor plates on the tub wall provide a shear surface, increasing the ability to process and reducing the fibre length of roughages.

Vertical mixers are the most common type found in small trailer mounted mixers, but are now also available in larger sizes for truck mounting.

Horizontal screw

Horizontal screw mixers consist of a series of augers mounted on a horizontal rotor in a hopper.

Horizontal screw mixing augers in the feed truck.

Auger mixers use one to four augers to churn the feed in a hopper. The flighting of the auger(s) moves the feed towards the middle of the mixer where it bubbles to the top, toward the sides and back down to the augers.

The mixers have one or two counter rotating auger(s) and/or flighting, moving feed in the opposite direction to the other augers. Feed moves from end to end and from bottom to top.

In many mixer designs, notched auger flighting and/or knife sections are attached to the auger flighting to process roughage and improve its incorporation into the ration. Design differences in these mixers include the number of augers, the rotation speed of the augers, the auger diameters and the auger flighting design.

Horizontal screw mixers are more efficient than vertical types in blending small quantities of liquids, or in mixing ingredients with different particle sizes. Liquids are generally placed in the mixer after the grain and roughage commodities to enhance thorough mixing and to prevent balling.

Paddle type mixer in the feed truck. The paddles can be seen under the loader bucket. Liquid supplement nozzles are under a shield.

Horizontal paddle mixer

The paddle type mixer is quickly becoming the predominant design used in larger feedlots in Australia. It can increase mixing efficiency, achieving soft mixing action for consistent grain integrity, consistency of the ration reduction in fines and speed of mixing.

The horizontal paddle type mixer combines a set of augers and a paddle in a hopper. The feed is lifted and tumbled by the paddle, moving it upwards to the upper and lower side augers. The augers provide a mixing action and move the feed from end-to-end. The rotor can be configured with three or more paddles (i.e. up to five or six). The paddles can also be staggered along the shaft of the rotor to match the ration density and improve mixing speed and performance.

The tumbling action mixes the lighter roughage and high moisture ingredients without grinding or high pressure feed movement. The side augers prevent dead spots and corner pile up.

These mixers usually discharge the mixed product from the bottom of one side, using the same mixer blade action. On truck mounted systems, the paddle and augers may be stopped or run while the truck is mobile, but must be working during feed delivery to aid the flow of feed from the delivery chute to the feed bunk.

Paddle mixers are available in various configurations, with mixing capacities typically ranging from 15 to 26m^3.

Stationary mixers

These mixers are permanently positioned and so require other equipment for feeding out the mixed ingredients to the feed bunks. The vertical feed mixer is often less efficient than the horizontal mixer because of its smaller size, restricting the level of liquid addition and requiring a longer mixing time.

Stationary mixers are typically driven by three-phase electric motors, the size of which depends on the type and capacity of the unit (e.g. screw, paddle). As a guide, a stationary paddle type mixer with a capacity of 15m^3 requires a 30kW electric motor.

This 5.5 tonne tractor drawn horizontal mixer requires 95–105kw at the PTO.

Mobile feed mixer

The mobile feed mixer can either be trailed (behind a tractor) or permanently mounted on a truck. These allow the feed to be mixed on the go before the feed is delivered, avoiding the need for double handling and giving faster turn around times. Tractor drawn feed mixers are commonly used in small to medium sized feedlots, with truck mounted mixers typically used in medium to large feedlots.

The truck mounted mixer increases feed mixing and delivery efficiency through faster delivery and less time for the ration to be mixed. The mounted mixer feeder caters for all types of ingredients in the ration formulation– from grains to liquids. Depending on the size of the feedlot, using more than one truck allows one to be delivering the feed while the other is being loaded. The most common types of truck mounted mixer feeders are the horizontal screw mixer and the horizontal paddle mixer.

Weigh scale

Weigh scales can be fitted to the loading unit (e.g. articulated, front end or telescopic loader), or to the mixer unit to accurately weigh and blend the ration ingredients. Electronic digital readout scales use load cells or weigh bar designs to weigh the loading of each ingredient in the mixer and are accurate to 0.25-1%.

The weighing system is usually supported at three or four points (cells) on the mixer chassis, depending on the design of the weigh sensors. The same weighing system is then used to measure the amount of mixed feed given to each pen of cattle.

Magnet

A magnet is attached at the discharge chute of the feed delivery truck to pick up metallic foreign material before it enters the feed bunk. This may be standard, or an option, on the mixer and should be considered part of a basic mixer system.

Safety

Safety should also be considered in mixer design and use. Metal steps or a ladder should be used to mount the mixer for inspection, while allowing for safe filling of the mixer.

Power take-off (PTO) shields should always remain in place and no safety shield should ever be removed.

Never try to dislodge wrapped hay from an auger or other moving part of the mixer while it is running.

Mixer sizing

The mixer size will be governed by the feedlot size, number of different rations being fed, ration density, feed intake and the number of times per day cattle are fed. Economics, labour availability and feed management will also help with decisions about mixer size

The capacity of a mixer is the total volume of the mixing compartment, but manufacturers may rate capacity at 60–90% and these figures should be followed.

Overloading mixers beyond the rated mixing capacity increases the mixing time required for a uniform mix and may result in spillage and feed wastage. This is particularly applicable to horizontal paddle mixers that rely on each paddle coming out of the feed at the top of its rotation to achieve proper mixing.

Typical bunker feed delivery system. The loader transfers ingredients to a truck mounted mixer, which then mixes on the go during delivery to the pens. Liquid supplements are loaded at a separate location.

Feed delivery systems

Feed delivery systems are generally planned during the design phase of a new feedlot. The optimal layout and design of the feedlot is often site and size-specific and this will ultimately affect which feed delivery system is best and the energy efficiency of the system. See *Section 2 – Feedlot site layout*.

The distance travelled to deliver the feed rations to livestock, often twice a day, makes fuel, labour and equipment costs a high priority in the design phase. The components of the feed delivery system, once installed, are not frequently changed because of the high capital costs involved with infrastructure construction. These may

be changed during major renovation of an existing feedlot, such as when increasing the feedlot capacity.

The feed delivery system will be determined by the type of feed-out system installed. Self-feeder bins are commonly used in small or opportunity feedlots, whereas open feed bunks are used in large or commercial feedlots. See *Section 19 – Feeding systems*. The components of various types of feed-out systems are discussed below.

The vehicle loading area is stepped down (or the commodity area raised) so the loader can load the vehicle safely and easily.

Bunker system

The bunker system consists of a storage shed where each feed commodity is stored in separate bunkers (see *Section 31 – Commodity storage*). Commodities are transferred from the bunker into a truck mounted mixer, tractor drawn mixer trailer or stationary mixer or a batch box using a front end loader or equivalent.

Each commodity has a predetermined weight, monitored by weigh scales mounted on the respective mixing equipment—loader, batch box or mixer/feed-out unit.

Liquid supplements are typically loaded through an overhead piping system, remotely controlled by the operator (see *Section 34 – Liquid feedstuffs*). The load is mixed thoroughly and delivered to open feed bunks at each designated pen. The weight of feed delivered to each pen is recorded using the weighing scales on the feed-out equipment.

The biggest inefficiency with this system is the time spent operating a loader between the various feed commodities, the time spent waiting for a feed truck to return for loading or, more commonly, feed trucks waiting in queue to be loaded when there is more than one feed truck. In smaller operations, feed-out operators can load their own mixer units.

A ramp installed at the edge of the commodity shed aids the loading of feed trucks.

Stationary mixer

This system uses a stationary mixer located adjacent to the commodity bunkers. The loader places the correct weight of each ingredient into the stationary mixer using the scales fitted to the mixer and the ration is mixed before the feed-out unit arrives. The fully mixed load is then augured into the unit.

Large feedlots can have more than one stationary mixer and these can feed a series of overhead storage hoppers—one for each ration. The feed-out unit can then be quickly loaded with a fully mixed ration from the storage hoppers. As the feed-out units do not have to mix, these can be much larger than conventional feed trucks.

However, using feed-out trucks without mixing capability usually means that failure of the stationary mixer will stop the feeding process.

Batch-box system

The batch-box system is designed to streamline the feeding processes;. It is similar to the bunker system, but incorporates a stationary side-dump batch-box. The side-dump batch-box is hydraulically raised and lowered, powered by an electric motor and controlled via remote control. The commodities for a batch of feed are loaded from the bunkers into the batch-box using a front end loader, or similar, while the feed-out units are delivering the current load.

The batch-box is mounted on load cells to record the weight of each ingredient added. Once the feed-out unit returns, the complete ration

is dumped into it in 30 seconds (minimum) and then mixed in the feed-out unit as it travels to the point of feed-out.

Dual batch-boxes are commonly used so that while one is tipping, the other is being filled. The boxes are mounted on a static load cell platform - potentially providing more accuracy than with a mobile feed truck.

The batch-box system reduces loading variability, allows a faster turn over of trucks and more efficient use of equipment. Feedlot feeding capacity could be increased with the existing mixing and feed-out equipment.

Batch-boxes can be installed in a new site development, or successfully integrated into existing bunker systems.

The key considerations for integration into existing bunker systems include

- Site selection
  - Maximise use of existing shed and structures – consider available area, height restrictions, foundations, power supply.
  - Minimise efficient travel distances for feed-out equipment – consider loaders, feed truck turn around.
  - Access to liquid ingredient delivery systems – consider liquids could be added separately before or after the batch-box.
- Site preparation
  - Modifications to infrastructure – consider foundations, sheds, liquid feedstuffs pipework, power supply.
  - Construction/installation of new infrastructure.
- Alternative feeding arrangements during construction/installation.

For new site developments, incorporation of a batch-box system needs to align with the location of the system, including proximity to liquid storages, travel distances from commodity storage bays and vehicle turn arounds. *Section 31 – Commodity storage* illustrates various commodity shed layouts with an integrated batch-box system.

The supplier of the batch-box system should be able to provide details such as foundation design and power requirements.

This dual batch-box system is located externally to the commodity storage. No liquid feedstuffs are added at this point.

A dual batch-box system installed at the end of the commodity storage. The loader can continue to load one batch box while the other is tipped into the feed truck. The front of the batch-box holds liquid dispensing equipment.

Mobile delivery equipment

The ration is transported from the commodity shed to the cattle using mobile delivery equipment. Mobile units include truck mounted vertical and horizontal augers, horizontal paddle mixers and tractor drawn auger and vertical screw mixers or non-mixer feed-out vehicles.

Larger mixers in mobile delivery equipment require larger and more powerful tractors or trucks. Equipment manufacturers will specify the power required to operate a particular mixer. A tractor is often dedicated to the daily operation of the mixer trailer.

A dual batch-box system installed inside and at the end of the commodity storage.

Feed management system

The feeding system, from ration mixing to delivery to the feed bunk, should be managed to ensure a consistent level of nutrients is presented to the cattle in a consistent form and a timely manner.

Selection of make and model of commercial feed delivery trucks is driven by personal experience and the size of the feedlot. This imported left hand drive truck delivers feed to the left.

A feed-out chute on the same side as the vehicle operator minimises spillage and wastage when dispensing feed (i.e. right hand drive vehicle with right hand side delivery chute). A rubber extension on this chute minimises damage from impact with the feed bunk.

There are several proprietary feed management software systems available (e.g. FY3000 Feedbunk, FeedIT and Possum Gully). The software systems are usually an integrated feedlot management system, with various management features and tools. Some feedlots (large and small) have developed their own feed management software.

Most of these integrated management systems import inventory data (e.g. cattle, feed), cattle treatments, feeding records and export financial data to financial and accounting software programs to generate detailed reports.

The feed management system must link the feeding system with the cattle management system (e.g. NLIS, animal health treatments). The commonly used radio frequency (RF) datalink (wireless) transfers feeding protocols and instructions to the feed preparation, loading and mixing areas.

This allows feedout operators to accurately determine ration formulations and load sizes, including weights of each ingredient to be included and mixed in each specific load.

The RF datalink is integrated with the feed delivery vehicles to ensure the actual weights of loaded ingredients and feed ration are allocated accurately to the intended pen.

The system will also capture the actual weight of each ingredient added to each load and the actual weight of mixed feed provided to each pen. This data is transmitted from the mixing equipment and the feed-out equipment directly to the feedlot office and captured by the feedlot's main computer system.

Quick tips

- Rations with a high percentage of roughage will require larger capacity mixing equipment.
- Selection of the most suitable type of mixer will depend on a wide range of factors.
- Select the mixer size based on budget, feedlot capacity, ration density, feed intake and number of times cattle are fed each day.
- The size and layout of the feedlot will determine the type, size and number of feed delivery vehicles required.
- Manufacturer claimed mixing times are often overly optimistic, even for ideal ingredient composition and conditions.
- Conduct a mixer test for each particular ration to determine the optimum mixing time for each particular mixer/ration combination and ration. This ensures that the ration is evenly mixed when delivered to the first pen.
- Batch-boxes increase the efficiency of feed delivery, especially in larger feedlots (e.g. greater than 15,000 head).

Further reading

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