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AUSTRALIAN Pork™

Group Demonstration Award – Increasing Feed Conversion Efficiency by Reducing the Bridging Effect in Feed Silos

Final Report
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Executive Summary

The Sure-Flo ® silo insert did alter the flow pattern of feed out of the silo but not the way that was expected. The feed exited the silo such that the feed sloped downwards on one side. The exact cause for this was unknown. The authors feel that there is no definite recommendation that can be made on the basis of the results of this trial. Whilst it is clearly evident that the inserts did change the flow patterns within the silo, it did not provide any of the expected benefits. Starter diets of 515µ particle size used in this trial are at the lower end of the average particle size that can be expected in mash diets. The diet formulations in use during this trial did not cause the flow problems that had been evident on this unit previously, which suggests that diet composition is also a factor of flow problems. Future investigation is required to determine if changes in feed flow would provide benefits with a wider range of diet formulations.

Background to Research

Reducing particle size in pig diets results in better feed utilisation and is estimated to produce a 1.3% increase in efficiency of gain for each 100 microns decrease in particle size. Whilst increases in feed efficiency can be gained by reducing particle size, bridging and flow problems in silos and feeders can result from this reduced particle size. If these flow problems can be alleviated and diet particle size can be reduced, significant saving could accrue to the Australian pig industry.

A 1.3% saving on a silo dispensing 10 tonnes per week represents a saving of $2700 per year if feed is $400/t. Hence investigating the operation of this equipment may provide benefits that are of significant interest to the Australian pork industry.

Feed bridging and flow problems in silos can also contribute to a number of other problems on the piggery. Often feed can bridge on the sides of the cone leading to feed remnants between batches which can give rise to mycotoxin contamination and subsequent problems that can arise. A side benefit is in the area of OHS – if silos empty with a more even flow the need for workers to climb to the top of the silo to see how much feed is in the silo will be removed. Some form of external measuring device may be able to be utilised.

This project investigated the commercially available Sure-Flo® insert that is designed to alter the flow of feed from silos and claims to reduce bridging and improve material flow from silos.

If material flow in silos could be improved and lower diet particle sizes can be used the benefits to the Australian pork industry could include:

- The ability to reduce particle size to capitalise on gains in feed efficiency knowing that bridging in silos will be less of a concern
- Will be of benefit to farmers bottom line
- Reduced feed out events and associated welfare and weight gain issues
- First-in/first-out feeding systems to improve the quality of feed presented and limit potential for microbial contamination
- A reduction in the OHS risk for farm workers having to climb silos to see how much feed is in the silo. If silos empty more evenly an external measuring device may be used to monitor silo content level. This will also reduce the need to make assessment of cone-up versus cone-down assessments in stocktaking on farm feed inventories. This may greatly improve feed ordering logistics.

Objectives of the Research Project

Objective 1: To Test the Sure-Flo ® Silo Insert in a Farm Situation with 3 Different Feed Mixes Used on Farm over a 6 Month Period.

Objective 2: To Determine if Feeds of Smaller Particle Size Can Be Delivered to Pigs as a Result of the Use of the Sure-Flo ® Device in Silos.

Objective 3: To Determine if a First-in First-out Feed Delivery System Is Created Using the Sure-Flo ® Device in Silos.

Objective 4: To Determine if Stock Take Accuracy and OHS Can Be Improved by the Use of the Sure- Flo ® Device in Silos.

Objective 5: To Determine if Feed-out Events Can Be Reduced by the Use of the Sure-Flo ® Device in Silos.

Objective 6: To Generate a Case Study that Can Inform the Australian Pork Industry of this Potential Strategy to Utilise Feeds of Smaller Particle Size to Improve FCR.

Objective 7: To Evaluate the Cost Effectiveness of this Strategy.

Introductory Technical Information

The flow of solids such as milled and mixed feedstuffs is dependent on a range of factors. These include:

- The material in question and whether it is affected by humidity or temperature, its oil content, fluffiness and how prone it is to cacking,
- The particle size range and dimension and whether they can form aggregates or bridges
- The silo dimensions in particular the angle or steepness of the cone and the outlet size
- The friction generated between the feedstuff and the silo walls

There are 2 main flow patterns which are funnel flow and mass flow.

Funnel flow is where a central channel of flow occurs, usually directly above the outlet, while the material around this flow is stationary. This pattern of flow results in the last-in/first-out feed distribution can reduce the effective capacity of the silo and result in stale or remnant feedstuffs lining the silo walls.

Mass flow refers to the flow pattern where all the material in the silo is moving but not necessarily at the same speed. This is the flow pattern that is desired in most feeding situations as it results in a first-in/first-out flow.

Sometimes there is a no-flow situation due to interaction between particles in the mix or silo characteristics or a combination of the 2. Research has indicated that there are a number of aids to flow that can be utilised to improve flow patterns. These include modifications to the cone which increase the slope, the use of liners and coatings on the cone wall to reduce friction, passive inserts in the cone to adjust the flow pattern, mechanical aids which can be grouped according to type – pneumatic, vibratory, and mechanical, and addition of substances which reduce caking or desiccants to

reduce moisture absorption.

Silo or feed bin attributes affect solids flow. According to Chase (Akron University) the required cone angle for mass flow to occur ranges from 40° to 0° from the vertical axis. Other factors affecting solids flow include the cone wall friction with the flowing solid and the size of the outlet. Too small an outlet and bridging may be more frequent and flow is inadequate. Cone wall smoothness is very important – a rough wall can promote funnel flow regardless of the cone wall angle.

In this trial we are examining the performance of a passive insert of the "inverted cone" design. Other passive inserts that appear in the literature include "cone-in-cone" and "double cone".

Research Methodology

The project was a farm demonstration trial to test the Sure-Flo ® silo insert – a commercially available product that claims to improve flow of solids out of silos. The farm was chosen for a range of reasons including large number of silos available for testing the insert as well as flow comparisons from silos with no insert fitted, regular turnover of feed in the silos, ability to test 3 different feed mixes flowing past the insert, and the interest in the outcome demonstrated by the staff. This farm also has its own feed mill on site, they use a disc mill so there is more control over particle size and they possess a set of automated sieves to calculate particle size. The project examined the effectiveness of retrofitting old silos with inserts and investigated the impact on feed flow and feed out events.

Six Sure-Flo inserts were purchased and fitted by the maintenance crew on the farm. All recording was undertaken by farm staff. Anecdote provided by Mike Brumm during a PigLink teleconference suggested that the devices could be expected to work well once the sides of the silo cone became shiny and smooth. When the inserts were installed it was reported that the insides of the silo cones were given a brush over with a wire brush to clean the surface.

Recording sheets were supplied to the farm and workers were asked to record any stoppages to flow that occurred during the period of the trial both in the silos fitted with the inserts and an equal number of silos that had no inserts.

Results and Discussion

Objective 1: To Test the Sure-Flo ® Silo Insert in a Farm Situation with 3 Different Feed Mixes Used on Farm over a 6 Month Period

Six Sure-Flo ® silo inserts were purchased through DHA Rural @ a cost of $253.00 per unit (includes GST and freight) and delivered to Goondiwindi during the week of the 25th July 2011. All 6 were inserted by mid-September 2011 as each silo was emptied at the end of each batch of pigs.

Comments by Mike Brumm (US Pig Farmer consultant), suggested that it could be several months before the full benefits of the Sure-Flo ® insert could be realised. As the inserts were retrofitted to old silos the cone of the silos was cleaned with a wire brush to facilitate the flow of feed down the edges of the silo cone.

The product brochure from Automated Production Systems which describes the Sure-Flo ® insert suggests that the insert is bolted to the hopper collar of new or existing feed bins/silos.

Installation of these 6 inserts was described as easy and took about 10 minutes. However they were

fitted about 3 inches further up the cone wall (See image 4).

One eco-shelter lost its roof cover in a windstorm. Unfortunately it was fed by a silo with a Sure-Flo insert. On a visit to Wilga Ridge 10th January 2012 this shelter had still not been covered/repaired for various reasons beyond the management's control. So there are no records from this silo as the shed remained empty.

Enough starter feed is put into the silo to last 2 weeks, about 4 to 5 days before the pigs enter the ecoshelters. All silos needed a knock to get flow started due to settling of the feed but then there were no other reported flow problems from any silo for any feed.

Objective 2: To Determine if Feeds of Smaller Particle Size Can Be Delivered to Pigs as a Result of the Use of the Sure-Flo ® Device in Silos

Particle size of the feeds was measured 20th September 2011 and 10th January 2012 and the average particle size is contained in Table 1

Table 1: Average micron size and raw material composition of the feeds

	20 September 2011			10 January 2012		
	Starter	**Weaner**	**Grower**	**Starter**	**Weaner**	**Growe**
Particle Size	563µ	599µ	-	515µ	640µ	**r**
% Wheat	63%	68%	3%	63%	68%	3%
% Barley			20%			20%
% Sorghum			35%			35%
% Chickpeas			15%			15%
% Soybean Meal	6%	10%	6%	6%	10%	6%
% Canola Meal			10%			10%
% Tallow	3%	3%	3%	3%	3%	3%
% Fishmeal	10%	5%		10%	5%	
% Whey Powder	10%	8%		10%	8%	

The range of micron size between the various feeds is quite large – over 200 microns between starter and grower. Staff reports indicated that there were no flow problems from any silo other than at the start of the batch feeding cycle or when the starter feed was static in the silo for approximately 4 days.

Flow can be affected by several factors which include the components of the feed as well as the particle size. On this farm over this period of time the combination of diet composition and particle size did not appear to be affecting feed flow in any silo, suggesting that it would be possible for the farm and feed mill to test a finer particle size mix for the grower feed in the future.

A comment by the mill manager would suggest that the only adjustment to particle size that could be achieved would be in the milling of the grain. Purchased meals and other fine ingredients are added at the particle size in which they arrive – there is no further processing other than mixing with other feed ingredients.

Photographs of the feed samples were taken and the particle size difference is obvious to the naked eye both within and between samples.

Objective 3: To Determine if a First-in First-out Feed Delivery System is Created Using the Sure-Flo ® Device in Silos

The Sure-Flo ® insert did change feed flow out of the silo but in an unexpected way. The funnel flow effect where the middle of the silo flows out first was stopped but the flow pattern then became a side-flow pattern where feed emptied faster on one side of the silo (Image 9). This flow pattern occurred in all silos fitted with the Sure-Flo ® silo insert.

The cause of the new flow pattern is unknown. It could be a result of uneven smoothness of the cone wall which in turn is affecting the flow, or the dynamics of the feed delivery system augur and its effect on the movement of feed from the bottom of the cone. It could also be a result of the shape of the pile resulting from the initial auguring of the feed into the silo.

Objective 4: To Determine if Stock Take Accuracy and OHS Can Be Improved by the Use of the Sure-Flo ® Device in Silos

Due to the unexpected side flow pattern the much anticipated benefits to OHS and stock take accuracy are not evident. As the silos did not empty evenly it was still necessary to climb the silos for inspections and stocktakes.

A side emptying pattern within the silo could be of concern due to uneven stress on the silo walls if the silo was filled to capacity.

Objective 5: To Determine if Feed-out Events Can Be Reduced by the Use of the Sure-Flo ® Device in Silos

According to farm records during this period there were no flow problems in any silo so no feed-out events occurred in this 6 month period. Therefore we can draw no useful conclusion for this objective.

Objective 6: To Generate a Case Study that Can Inform the Australian Pork Industry of this Potential Strategy to Utilise Feeds of Smaller Particle Size to Improve FCR

The results from this short trial suggest that particle size is not the main problem when the flow of feed is impaired. Weather conditions did not appear to affect feed flow. There were days of 90% humidity and above average rainfall with no reports of any feed flow interruptions on this farm.

Objective 7: To Evaluate the Cost Effectiveness of this Strategy

The initial results of this trial period would suggest that fitting of the Sure-Flo ® insert to the older feed silos may not be cost effective. There were no evident benefits for OHS since the 'side-flow' flow pattern still requires someone to climb the silo for a stocktake, and there is no evidence of significant impact on first-in first-out flow.

However if the flow pattern is directly related to the smoothness of the sides of the cone then it could be anticipated that the flow pattern might change over time. In older silos it would be anticipated that this may take considerable time if this was to occur. Perhaps if the Sure-Flo inserts were fitted to new silos the results may be different. Also there may be a better result with whole grains for example as opposed to processed feed mixes. Anecdotal evidence suggests that these units are standard and fitted to new silos in the US.

Implications & Recommendations

The Sure-Flo ® silo insert did alter the flow pattern of the feed out of the silo but not the way that was expected. The feed exited the silo such that the feed sloped downwards on one side. The exact cause for this was unknown but could be related to the initial auguring into the silo, the pattern of removal by the feed augur operating at the bottom of the cone, or by the feed particle friction with the cone walls. The co-operators have been approached to leave some of the silo inserts in place for a further 12 month period to see if there is any change in flow pattern in the longer term. The co-operators have also indicated a willingness to move one of the inserts into a new silo at some point in the future when a new silo is installed.

Flow of solids out of a silo is dependent on the silo design, surface friction, characteristics of the solid as well as temperature, humidity and moisture content or oiliness of the solid. Raw material composition of pig diets is a key factor in the flow of the diets from the silo. The interaction of raw materials such as tallow and small particle size may dramatically impact on the flow of different diets. As this trial used only the diets that were in use at the time of the trial some of these factors were not evident. Having the inserts in place for a longer period of time, over which diets change through seasonal changes in raw material availability, will provide an opportunity to gain a greater insight into the functionality of these inserts.

The authors feel that there is no definite recommendation that can be made on the basis of the results of this trial. Whilst it is clearly evident that the inserts did change the flow patterns within the silo, it did not provide any of the expected benefits.

Diets at 515µ particle size are at the lower end of the average particle size that can be expected in mash diets. As only the grain component of the diet can be manipulated there is limited scope to reduce this in starter feed however the feed photos (Image 10) indicated some scope to reduce the particle size of the grower feed. The diet formulations in use during this trial did not cause flow problems that had been evident on this unit previously. With some of the inserts remaining in silos there will be an opportunity to see if any of the expected benefits are evident in diets that present more issue with flow in the silos

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Publications Arising

PigBytes Newsletter article
Australian Pork Newspaper press release

Photographs
Sure-Flo ® Silo Insert

Image 1: Greg Mills, Alan Hudson and Geoff Fisher examining the Sure-Flo® silo insert before installation.

Image 2: Geoff Fisher and Greg Mills (arm) discussing the Sure-Flo® insert. It can be noticed that the insert is not rigid – there is some movement possible side to side on the vertical rod that passes up through the centre of the cone.

Sure-Flo ® Silo Insert Fitted in the Silo

Image 3: Sure-Flo® silo insert fitted in the silo – looking down from the top hatch.

Image 4: The bolts visible on the outside of the cone indicate where the Sure-Flo® silo insert sits in the silo. The product brochure suggested that the insert should be down in the collar or neck of the silo.

Silo Attributes

Image 5: Cone angle is important for good flow – for mass flow to occur the recommended angle is 40°from vertical axis (Chase Akron University) – these silos appear to be of the right shape. This is a photo of some of the small silos.

Image 6: One of the large silos relative to shed – its cone looks to have the right angle to encourage mass flow. Greg Mills and Geoff Fisher in front of shed.

Silo Cone Wall Condition Is Important

Image 7: There is less resistance to flow if the walls are smooth and shiny. The internal surface in this silo cone almost looks rusty in places.

Image 8: Feed residue on walls of the cone has collected in the dents resulting from knocks to the cone walls over the years.

Image 9: The feed in the cone is emptying from one side of the cone, leaving feed piled up on the other side of the cone

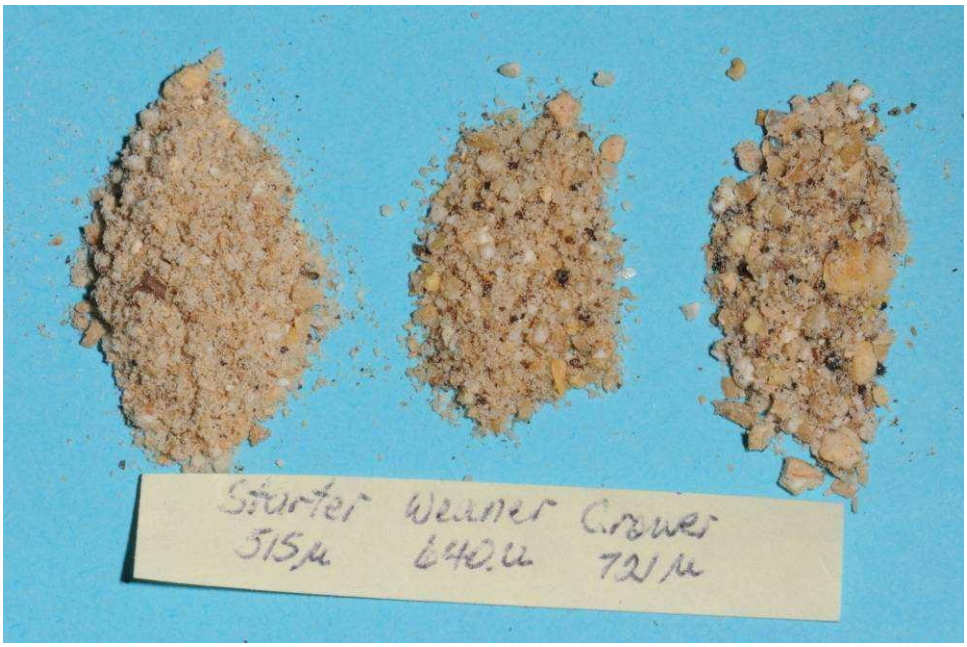

Image 10: Feed particle size comparison (photography John Hosking).

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