final report

Project Code: P.PSH.0363

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Date published: June 2008

PUBLISHED BY
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Solids Removal & Grit Recovery by Hydrocyclone

This is an MLA Donor Company funded project.

Meat & Livestock Australia and the MLA Donor Company acknowledge the matching funds provided by the Australian Government to support the research and development detailed in this publication.

Executive Summary

The Wagga Wagga beef processing facility of Cargill Beef Australia (CBA) processes a high proportion of lot-fed animals. These animals import a significant quantity of sand and grit which is washed into the wastewater streams, especially the cattleyards and paunch-opening streams. The grit (approximately10m^3/week) settled out in the saveall pits and the downstream Dissolved Air Flotation (DAF) plant resulting in loss of treatment efficiency and the need for external contractors to regularly come to the site and clean out the settled grit and sand.

On the recommendation of Johns Environmental, CBA installed a degritting hydrocyclone (pictured below) to remove grit and sand from its wastewater streams. The unit was commissioned in November 2008 and has operated successfully for a year.

Although similar to deoiling hydrocyclones used to recover fats and oils in the industry, the degritting hydrocyclone is more robust in construction to allow for wear from grit over its lifetime. Feed enters tangentially to the main body of the unit, degritted wastewater exits the top orifice and a solids-rich stream is discharged through the duckbill valve at the base of the unit. Approximately 4 wet tonne of grits and sand with some paunch solids have been recovered daily since commissioning.

The total cost for purchase and installation was $104,000 for a unit capable of processing the entire wastewater flow (~ 270 m^3/hr). Operating cost is approximately $3,700 p.a. Since commissioning the hydrocyclone has eliminated the need for regular desilting of the DAF unit downstream – saving in the order of $40,000 p.a.

The operation of the unit is reasonably trouble-free, with some occasional blockages of the duckbill valve due to the stickiness of the paunch-contaminated silt. However these are easily cleared.

The operation of the unit can be further enhanced by:

- Applying it only to the cattleyards and green streams, which carry the highest silt load, since the unit prefers high solids loadings;
- Improved pre-screening to minimise paunch material, which assists blockages;
- Intermittent operation to minimise power consumption and improve dryness of the solids discharge.

The unit is suitable for any meat processing plant experiencing problems with silt and sand settling in their system.

Contents

1 Background

1.1 Project Drivers

Cargill Beef operates a large beef processing plant at Wagga Wagga, which processes a high percentage of feedlot cattle. These import a large load of fine grit and sand, which ends up in the various wastewater streams; particularly the cattle yards wash stream and the offal processing streams (due to high grit and sand loads in the paunches). This material then settles in savealls, DAFs or ponds where they reduce treatment volume and are labour intensive to remove.

There were two main drivers for this project:

- Inorganic solids in the wastewater streams onsite was an ongoing problem resulting in wear and tear on pumps and seals;
- Grit and sand settle in the combined stream DAF requiring the DAF to be cleaned out on a weekly basis at considerable expense.

1.2 Degritting Hydrocyclone Technology

Cargill Beef contracted Dr. Johns of Johns Environmental Pty Ltd to conduct a performance assessment of the existing wastewater treatment system at the Wagga Wagga site. Dr Johns recommended trialling degritting hydrocyclone technology as a cost efficient means of removing heavy inorganic solids and grit prior to further primary treatment.

1.2.1 Hydrocyclone Technology in the meat Industry

Hydrocyclone technology has been trialled and installed in meat processing plants since about 2001 for the main purpose of removing oils and fats from hot effluent streams. These are deoiling hydrocyclones in which the oils are recovered in the light phase and water leaves the unit in the heavy phase.

An excellent description of this technology and its applications in the Australian red meat processing industry is given in the Meat & Livestock Australia (MLA) report (MLA : 2003). Consequently the technology is not foreign to the industry.

1.2.2 Degritting Hydrocyclones & Competing Technologies

Due to the rapid settleability of sand and grits, technologies for their removal from wastewater streams include:

- Grit settling channels;
- Primary settling devices such as clarifiers, or aerated grit chambers;
- Vortex units;
- Centrifuges;
- Hydrocyclones.

Settling channels and clarifiers are large footprint devices often with significant liquid residence times. The risk of offensive odours from these devices makes them poor choices for the task in meat processing plants, especially where unsightly, vermin-attracting fatty scums rapidly form on even aerated units.

Vortex units operate in a similar manner to hydrocyclones, but are less compact. They are an alternative to hydrocyclones that has been successfully installed in several sewage treatment plants.

Centrifuges – especially decanter models – are highly effective at removing heavy material from wastewater. However, they are expensive both to purchase and to operate, especially where large wastewater volumes must be processed.

Hydrocyclone technology has been widely used for separating particles with a specific gravity exceeding that of water (SG > 1.05) for several decades. Examples include:

- Grit removal in vegetable processing.
- Separation of raw starch granules from water in the starch processing industry
- Removal of fines in the coal washing and mineral processing industries.

Hydrocyclones can also be used to classify particles on the basis of size and density. To the best of our knowledge, degritting hydrocyclones have only rarely been applied to abattoir effluent. Figure 1 indicates how the unit works and shows a typical deoiling unit.

1.2.3 Benefits of Hydrocyclones

The primary benefits of using hydrocyclones to treat waste streams contaminated with heavy grits and sands include:

- Simple and robust technology;

- No moving parts – all the momentum is provided by the hydrocyclone feed pump which causes the incoming feed to enter tangentially near the top of the unit. The tangential action sets up a classifying vortex within the unit which performs the separation;

- No need for chemical or air addition;

- Unaffected by temperature;

- Automatic and intermittent dumping of collected grit as a “dry” solid suitable for composting or disposal.

Figure 1. Hydrocyclone processing module at Wagstaffs Abattoir, Cranbourne

1.2.4 Vulnerabilities of Hydrocyclones

The key vulnerabilities of the technology lies in the risks associated with frequent blockage of the discharge nozzles – for example by paunch contents and oil & grease. This risk needs to be addressed in the design to ensure robust operation. It has been a problem with deoiling units which typically have small orifices prone to blockage by balls of paunch and other solids.

Degritting hydrocyclones tend to have larger orifices which are less susceptible to blockage. Nevertheless appropriate pre-screening is essential for robust operation.

2 Project Objectives

2.1 Project Objectives

The main objectives of this project were to:

1. Identify the best design and installation for a degritting hydrocyclone;

2. Demonstrate to industry the robustness and efficiency of degritting hydrocyclone systems.

3 Installation

3.1 Description of Hydrocyclone

A single degritting hydrocyclone was designed by K2 Corporation and installed by Nalco. The unit is a mining (Model 4450 CI/30) chrome iron hydrocyclone with sintered alloy nozzle. The body material is about 30 mm thick to allow for grit wear over its life. Table 1 presents design parameters for the unit.

Figure 2 is a schematic process flow diagram which indicates the positioning of the hydrocyclone within the existing primary treatment train at Cargill Wagga Wagga. The hydrocyclone treated all wastewater from the facility.

Pretreatment was as follows:

- The red stream was first screened through a rotary contrashear screen and the subject to Dissolved Air flotation to reduce TSS and oil and grease.

- The cattleyards and the green streams were passed through a coarse screen screw press and then screened using a shaker screen.

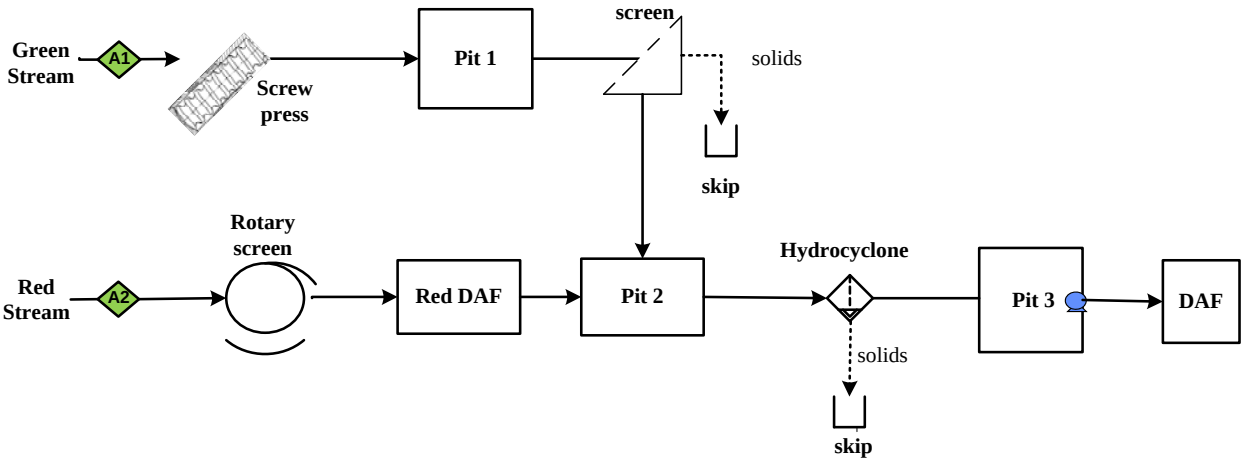
- The red and green streams were combined in a pit from where the pit contents were pumped to the hydrocyclone.

Flow to the unit comes from the combined red and green stream pit using a Flygt HP HT series rubber lined pump (22 kW) rated at 270 m^3/h delivery to the unit. Supply piping was 150 mm dia. PE piping.

Table 1. Main design parameters for the Cargill unit

Parameter	**Units**	**Value**
Design flow	m^3/h	250 - 300
Design SG		> 2.6
Feed		Combined green & red streams

Figure 2. Schematic showing the positioning of the hydrocyclone in the treatment system



Figures 3 and 4 illustrate the simplicity of the unit and its arrangement. The unit is designed to remove sand and heavy grit after preliminary screening to eliminate large objects that might block or damage the unit.

Figure 3. Hydrocyclone mounted on support structure showing bin for grit collection

Figure 4. Hydrocyclone showing tangential feed (black piping), exit degritted water stream (top white pipework) and the duckbill valve for intermittent sludge discharge.

3.2 Hydrocyclone Commissioning

The unit was commissioned successfully on 12th November 2008 and removed approx. 2 m^3 of heavy grit material during initial operation. Since high quantities of grit are not always present in the feed to the unit, the duckbill solids discharge nozzle is important in ensuring that there is not an excessively wet solids discharge.

The discharged solids fall into a ~ 1 m^3 bin with small (~ 3 mm diameter) drain holes to allow drainage of excess water back to the saveall area. The filled bin is transported by forklift to the sludge handling area.

4 Long Term Operation

4.1 Operational Performance

The hydrocyclone has operated successfully at the Cargill plant for over a year. The unit removes approximately 4 tonne/day of wet grit (~1,600 head/day), comprising mainly sand with some paunch contents. This is dried and sent for composting.

The unit requires minimal supervision and is entirely enclosed which minimises the risk of odours or unsightly operation.

Prior to the installation, the downstream Dissolved Air Flotation (DAF) unit required shutdown and pump out of accumulated silt on a fortnightly basis. Since commissioning the hydrocyclone, the DAF unit has not required cleaning, ensuring that it operates a maximum efficiency.

4.2 Financial Analysis

Table 2 provides the breakdown in capital and installation costs for the hydrocyclone. These totalled $104,000. The unit is very large, processing 270 m^3/hour of effluent.

Table 2. Installed capital cost of the Hydrocyclone

Item	**Amount**	**Comments**
Hydrocyclone	$95,000	Includes supporting structure & piping
Foundations	$7,000	
Electrical	$2,000	
Total	**$104,000**	

Table 3 estimates the payback for the unit. Maintenance is estimated to be about 1.5% of installed cost annually with pump power of the order of $2,200. Savings reflect the elimination of the need for a contractor to come in fortnightly and remove silt from the DAF unit downstream. A payback of about 3 years is required.

It should be noted that the unit is probably over-sized for the application and a smaller unit could be installed – see the recommendations section.

Other savings in terms of wear and tear on effluent pumps and pipes and loss of treatment volume in the anaerobic ponds due to silt deposition are not accounted for. However, these issues become more significant as the industry moves to covering its ponds to minimise methane emissions.

Table 3. Payback Estimation

Item	**Amount**	**Comments**
Capital cost	$104,000	Includes supporting structure & piping
Operating cost: - Maintenance - Electricity **Total OPEX**	 $1,500 $2,200 **$3,700**	
Savings	**$37,700**	On contractor not required to desilt DAF
Payback	**3.1 years**	

4.3 Potential Improvements

Overall t he hydrocyclone has operated very well and robustly. Some comments include:

4.3.1 Suitability of Waste Streams

The hydrocyclone processes the total wastewater stream at Wagga Wagga. However the main grit-containing streams are:

- Cattleyards effluent;
- Paunch stream.

Consequently treating the entire wastewater stream through the hydrocyclone results in a low feed solids content. Initially this resulted in excess water spraying from the solids discharge port. This was solved using a duckbill valve to permit intermittent solids discharge.

However, it is arguable that the degritting hydrocyclone is best used on segregated cattleyards and paunch effluent streams rather than the total wastewater flow. This would permit installation of a smaller and cheaper unit and allow higher solids loadings to the unit for more efficient operation.

4.3.2 Paunch Material

It is important to remove as much of the paunch suspended solids from the green stream as possible prior to degritting. Any of the common types of equipment should serve for this purpose including screw press, or screens with about a 1 mm aperture.

It has been found at Cargill that the mix of low levels of grits and high levels of paunch with its fatty nature can form a sticky material which causes partial or even full blockages at the solids discharge nozzle of the hydrocyclone. While this is readily unblocked, it is preferable to minimise the possibility by good pre-screening.

4.3.3 Mode of Operation

At Cargill, the screened green streams mix with the rotary-screened and DAF treated red stream in a pit prior to pumping through the hydrocyclone. The grit material settles rapidly in the pit and is then pumped to the hydrocyclone. Intermittent operation of the hydrocyclone is probably preferable to continuous operation (although the unit is capable of either), since it allows the pump to send high solids loads to the hydrocyclone.

It is important that the pre-hydrocyclone pump pit accumulates the settled silt near the pump intake to minimise the build up of grit “banks” in areas where the pump is unable to access them. One option is to allow for a mix arrangement to move the silt towards the pump intake and/or to keep it in suspension (although this is energy-intensive).

Once a week the pit should be drained and any residual settled grits hosed to the pump intake and removed through the hydrocyclone.

5 Success in Achieving Objectives

The degritting hydrocyclone has been successfully installed and commissioned. For over a year it has operated robustly and performed well. In particular it has solved the problem of excessive sand and grit settling in the downstream DAF unit.

The solid grit discharge is easily handled and sent for composting as an admixture with the paunch solids.

6 Conclusions

1. The degritting hydrocyclone has operated successfully at Cargill Beef Wagga Wagga for over a year removing heavy grit and sand from the wastewater stream and protecting downstream treatment units from volume loss due to settled solids.

2. The approximate payback for the installation was 3 years. However, this is based only on the savings in desludging the DAF. Other savings such as longer pond life – especially once covered – are not incorporated. Further, if a smaller unit was purchased to treat only the cattleyards and paunch streams the payback may be of the order of 2 years.

3. The solids discharge is recovered as a high solids content stream that is suitable for composting.

4. The unit needs pre-screening to protect it from excessive blockage, especially by paunch. However, the orifice has a much higher diameter than the deoiling hydrocyclones, which suffer badly from paunch blockages.

7 Bibliography

MLA (2003). *Assessment of hyrocyclones for fat removal from Meat Processing wastewater Streams*. Prepared by GHD Pty Limited., October 2003, North Sydney.