



final report

Project Code: P.PIP.0140

Prepared by: KEITH ENGINEERING (AUSTRALIA)
PTY. LTD.

Date published: March 2006

PUBLISHED BY
Meat and Livestock Australia Limited
Locked Bag 991
NORTH SYDNEY NSW 2059

SLUDGE AND WASTE STREAM PILOT SHS DRYER TRIALS AUSTRALIA MEAT HOLDINGS

This is an MLA Donor Company funded project.

Meat & Livestock Australia acknowledges the matching funds provided by the Australian Government and contributions from the Australian Meat Processor Corporation to support the research and development detailed in this publication.

This publication is published by Meat & Livestock Australia Limited ABN 39 081 678 364 (MLA). Care is taken to ensure the accuracy of the information contained in this publication. However MLA cannot accept responsibility for the accuracy or completeness of the information or opinions contained in the publication. You should make your own enquiries before making decisions concerning your interests. Reproduction in whole or in part of this publication is prohibited without prior written consent of MLA.

Activities.

The basis of the following trials was to prove firstly whether a super heated steam dryer could adequately dry Australia Meat Holding's waste streams and secondly whether the efficiency of this process will fit in line with the overall project.

The trials were run over a period of five days, the first three days on week one were used for obtaining machine set points and operating temperatures and on week two the last two days were used to obtain energy figures that are represented in the mass balance.

Pilot Plant Description.

The pilot plant used on the trials is a small portable version of Super Heated Steam Dryer capable of a maximum evaporation rate of 125kg/hr depending on the material presented.

Its uses super heated steam at atmospheric pressure instead of hot air as its drying medium and it is used in an oxygen free environment.

The pilot plants heat source is generated from electric heating coils, which heats the steam entering the drum to the desired temperature. The fan generates the required steam velocity, which helps convey the material inside the drum to the discharge conveyor.

Raw material enters the dryer via a feed hopper that has a constant airlock of product to stop oxygen ingress. Material cascades through the drum by lifting paddles. Dry material exits the dryer in a discharge conveyor that also keeps an air lock to stop air ingress. A cyclone is connected to catch any lighter particles that are picked up by the return steam preventing them from entering the heat exchanger or in the pilot plants case the heating coils.

Any excess steam that is not reused in the heating process is expelled to a plate heat exchanger to condense the steam. A small amount of non-condensable gases are discharged from the plate heat exchanger.



The Super Heated Steam Dryer on site at Australian Meat Holdings

The pilot plant is controlled by a computer using Citec and Scada operating systems via touch screen control.

Trial 1. Belt press sludge.

Raw sludge was collected from the belt press as it entered the Sludge holding trailer from the discharge screw conveyor. This raw material was tested for moisture and a reading of 83 to 84% moisture was taken. This material was then shovelled into the dryer hopper as required. Different feed rates, temperature settings, drum speeds and fan speeds were trialled until a suitable product was discharged from the dryer.

We discovered that 350°C was a good inlet temperature to begin feeding product into the pilot plant and no problems were noticed at this temperature. On a full scale version this temperature may be increased to help with efficiency. The product was initially fed to an air environment and we used the steam that was flashed off to purge the system of this air, normally a steam environment would be attained before feeding product but due to the high moisture content of the sludge the super heated steam environment inside the dryer was obtained very quickly and no sticky phase was noticed.

On a full-scale model and since steam is readily available at AMH a pipe could be connected to the dryer to firstly induce the super heated steam environment and secondly to get the dryer to operating temperature faster.



Raw sludge introduced to the dryer.

Sludge in various stages of drying cascades inside the drum via lifting paddles and is conveyed through the dryer drum by a combination of steam velocity and drum rotation speed. Dried product remained inside the dryer discharge hopper until a plug was achieved and then the discharge screw speed was set to maintain a constant out feed rate.

The first of the product discharged had a low moisture content of around 5% as the dryer drum had no load and therefore dried quicker. As the drum filled with product the moisture level discharged balanced out and a consistent discharge moisture content of between 12 and 16% was achieved.



Dried sludge discharged from the dryer.

As the dryer works at atmospheric pressure any excess steam from evaporation of the raw product that is not reused in the drying process was purged out and condensed in a plate heat exchanger and on further trials was expelled to atmosphere (by-passing the plate heat exchanger). This expelled steam also contains non-condensable gases that contain an odorous element. This odorous gas has been sampled and will undergo further tests.

Trial 2. Waste stream mix.

A mixture of paunch, save all No.2 solids, DAF float and truck wash solids were combined and dewatered to 70% moisture and then mixed with 83% moisture belt press sludge through a mincer machine to achieve even mixture. This mixture was found to have a moisture content of approximately 76%.

The inlet temperature was kept at 350°C, drum and fan speeds were reduced to try and cope with the smaller lighter grass type particles that would travel with the steam velocity. Some carry over through the cyclone was noticed as a smoke discharge due to small particles burning on the heating coils. Full scale models wouldn't have the smoke problem due to the heating loop being separated from the product and steam loop via a heat exchanger.



Waste stream raw material mixture.

Feeding of the mixed raw materials went through without any help compared to the straight sludge that needed constant manual prodding to get it to feed properly.

It was noticed that the mixture of materials seemed to dry easier and a larger volume could be discharged compared with the straight belt press sludge. This was put down to the fact that the smaller grass particles could be dried easier and the product as a whole gave up its moisture more efficiently



Waste stream mixture end product

Moisture of the end product was taken down to as low as 5% although with the lower moisture content it was noticed that the dust particles did increase in volume.

From the trials we can deduce that any moisture content required can be achieved through this drying method.

Mass balance:

Based on the pilot plant trials we have calculated the figures received on a pilot based worse case scenario and an expected percentage saving from plant modifications.

Belt press sludge

Energy consumption per kg of evaporation = 4.56MJ/kg (based on actual pilot trials)

Total raw belt press sludge per day = 63,000kg @ 84% moisture

Total moisture = 52,920kg

Total solids = 10,080kg

Dried end product to have a moisture content of 15%

Total mass of finished product = 11,859kg per day

This leaves 51,141kg of moisture to be evaporated in 18 hours = 2,841kg/hr

2,841kg/hr x 4.56MJ/KG x 18 hours = total daily energy use of 233,189MJ

Waste stream mix

Energy consumption per kg of evaporation = 3.66MJ/kg (based on actual pilot trials)

- **Based on 10% finished product moisture**

Total raw material mixture per day = 150,000kg @ 76% moisture

Total moisture = 114,000kg

Total solids = 36,000kg

Dried end product to have a moisture content of 10%

Total mass of finished product = 40,000kg per day

This leaves 110,000kg of moisture to be evaporated in 18 hours = 6,111kg/hr

6,111kg/hr x 3.66MJ/KG x 18 hours = total daily energy use of 402,593MJ

- **Based on 40% finished product moisture**

Total raw material mixture per day = 150,000kg @ 76% moisture

Total moisture = 114,000kg

Total solids = 36,000kg

Dried end product to have a moisture content of 40%

Total mass of finished product = 60,000kg per day

This leaves 90,000kg of moisture to be evaporated in 18 hours = 5,000kg/hr

5,000kg/hr x 3.66MJ/KG x 18 hours = total daily energy use of 329,400MJ

The energy figures quoted are total for the entire process, which includes motors, screws, lights and heating coils. The above figures don't include any energy recovery of waste heat streams that may be able to reduce the energy costs of the dryer.

Energy savings

We would be comfortable at this stage to offer a guaranteed energy saving of 7 to 10% on top of the above quoted belt press sludge figures.

We believe that through plant optimisation, product delivery and feed systems that we should be able to get the energy figure on the belt press sludge down to approximately 3.70MJ/KG of evaporation and lower but could not guarantee this figure or lower figures unless further trials were undertaken to prove this.

On the raw material mixture we are able to guarantee an energy saving of approximately 5 to 7% on top of its current energy rating. As this product was more suited to the way the pilot was set up at the

time of the trials it is envisaged that further substantial savings under the 3.40MJ/KG would be hard to come by.

Conclusions:

- The Super Heated Steam Dryer dried all raw materials presented to a desired moisture content and we experienced none of the problems associated with conventional drying technology.
- No back mixing of product is required and at no stage did the dryer experience a “sticky phase” with any of the materials presented for drying.
- Due to the physical nature of the sludge and the way it was presented to the dryer drum a higher than originally quoted energy figure was realised. This figure would be reduced with a more efficient feed system and a longer drum for product retention.
- The dryer does exhaust a small amount of non-condensable gas, which has an odorous compound. This gas has been sampled and results will be forwarded to AMH.
- The dryer is capable of processing the sludge and waste stream mixture at lower operating temperatures (350°C) although at higher temperatures it is expected that the energy efficiency will increase as the temperature rises. The Super heated steam heat to energy curve is higher than that of conventional air dryers.
- A condenser would be required to condense the surplus steam generated in the drying process.
- The sludge feed system on the pilot plant was labour intensive and a new system would be designed on a full-scale model to feed the sludge more consistently and in smaller particle sizes to aid in drying efficiency.
- The waste stream mixture that was presented to the dryer was easier to feed, dry and was more energy efficient. The waste stream mix was lighter and contained a lot more dust particles in its dry state.
- The waste stream mix would require multiple cyclones or a more efficient cyclone to reduce the carry over into the heat exchanger.
- We believe that the figure for waste heat recovery can't be accurately quoted as the theory and practice involved with waste heat recovery figures very rarely match up. Using the heat from the burner exhaust to preheat the air going to the burner will increase the overall efficiency of the dryer but to what extent can only be guessed at this stage. Using the waste steam from the dryer to further reduce energy costs could come in the form of using the hot water from the condenser to pre-heat the sludge in a jacketed screw conveyor. Again this figure I believe can only be an assumption.
- The only indicative energy figure we have at this stage is 4.5MJ/KG for sludge and 3.6MJ/KG for the waste stream mix. We also know that we can reduce these figures by redesigning the feed system, using the waste heat from the burner loop to pre-heat the air entering the burner and using the waste steam to heat water in a jacketed conveyor to pre-heat the raw material. What results these modifications will have on our overall energy performance can only be theorised at this stage.

Recommendations:

If the energy figures supplied minus the assumed savings via the modifications don't add up to your budgetary figures for the entire project, further experimentation should be carried out. Some previous trials in the form of coagulating the wet sludge have shown some promise and would present the sludge to the dryer in a form that would increase the energy efficiency.

Please note that reducing moisture content through heat transfer is the most uneconomical form of evaporation and if the moisture content of the product provided to the dryer was around the 55% to 60% mark from the above example huge savings would be made in gas usage and would offset the capital expenditure for the extra equipment.

We hope that the above draft report supplies the necessary information required for the project to continue to move forward.

Yours faithfully

Anthony Boarer
Keith Engineering (Australia) Pty Ltd

-

Project Manager