

Conditioning meals upstream of pellet mills Audit results

1. Introduction

This sheet presents a summary of the 17 audits conducted by Tecaliman over the course of the period between May 2000 and June 2001.

2. Feeds

In the majority of cases, the pressed feed is pig feed (9 audits), compared to 6 audits for poultry feed and 2 audits for cattle feed.

The average grain size of feeds is 0.651 mm. This value represents a shift in the operation of grinders towards the production of larger size particles. This shift can be explained by taking more account of animals' requirements and/or a need, in premixing process flow diagrams, not to limit the plant's throughput at the grinder.

3. Pellet mills

3.1. Pellet mills operation

The meal's temperature set points following the injection of steam are extremely variable and, in general, low in comparison with the data observed previously by Tecaliman for formulae intended for poultry. They do not appear to be defined in relation to a maximum efficiency target for pelleting facilities or durability. It is possible that the introduction of enzymes into formulae is the cause of this phenomenon (a destruction temperature of between 75 and 80°C), or quite simply that operators limit the introduction of steam for reasons of "convenience" (to eliminate the risks of pellet mill stoppages).

3.2. Installed capacities and performances

The pellet mill motors have rated capacities of between 150 and 270 kW. Power consumption represents between 46 % and 92 % of the rated capacity. Seven pellet mills pelletise with a load of below 70%, i.e. under conditions that do not enable the pellet mill motor's maximum efficiency

to be guaranteed.

Generally speaking, power consumption matches temperature variations at the conditioner outlet and there is a minor link between the cohesion of pellets and the specific consumption of pellet mills.

The average specific consumption of pellet mills is 16.8 kWh/t, which is low. This is probably due to the "Eurotest" durability level of pellets, which is low: 85.4% on average, as well as the throughput used to calculate specific consumption, which is an instantaneous throughput.

In conclusion, the various situations examined during the course of these audits demonstrate that the efficiency of pellet mills is above that generally observed, but that this improvement in the energy performances of pelleting lines is probably due more to a low pellet quality requirement than to a desire to make electric energy savings for press motors.

4. Steam generation

Steam generation facilities have capacities that exceed plants' steam requirements (group of pellet mills, heating liquids).

For regulatory reasons (application of the order of 1st February 1993), all of these facilities were upgraded in 1996 - 1997 and are in a good condition.

The temperature of the feedwater is generally low, as 65 % of the temperatures of the water in tanks are below 60°C. This has no effect on the supply of steam to pellet mills, as these plants have boilers with excess production capacity.

The majority of plants use the heat from condensates or fumes to preheat the boiler feedwater.

5. Steam distribution

5.1. Condensate extraction

- 41 % of facilities have a trap separator at each key point of the circuit (cylinder, pressure release control, modulating

valve). This device ensures that dry saturated steam is supplied to the conditioner and protects the pressure release control and modulating valves governing the mechanical action of condensates.

- 23.5 % of circuits are affected by a malfunction of the condensate trap and separation systems:
- in one plant, the pressure release - control valve trap is fitted upside down and cannot operate.
- two plants do not have trap separators at the conditioner intake, i.e. upstream of the modulating valve.
- one plant has no continuous drainage for the modulating valve trap and draining is carried out manually.
- It should be noted that, during measurement campaigns, these malfunctions had no effect on pellet mill operation (die stoppages). This may be due to:
- a short steam circuit and effective removal of condensates by other traps located within the circuit (3 plants).
- a small quantity of steam introduced into the conditioner (1 plant)
- high steam pressure following a pressure release (1 plant)

5.2. Steam pressure at the modulating valve

Following a pressure release, the average pressure is 2.1 bar, but for all 17 circuits audited, significant dispersion of this variable is observed (from 0.9 to 4 bar). The high or low pressure options chosen by the plants have no objective justifications.

Variations in steam pressure after a pressure release are observed in five facilities. This malfunction of control-pressure release valves causes a fluctuation in the quantity of steam incorporated into the meal, the processing temperature and the pellet mill's power consumption (4 plants).

This phenomenon is cyclical in two plants and, to prevent the pellet mill being stopped, the pellet mill operator restricts the processing temperature. In one case, it is the cause of a press stoppage (1 plant).

The pressure release control valve in one plant leaks in the closed position (i.e. when the pelleting line is stopped). This translates into steam pressure in the feed circuit for the modulating valve that is equal to the boiler pressure (7 bar). This situation causes a press stoppage on start-up. This is due to the excessive quantity of steam introduced into the conditioner.

All these malfunctions affecting the steam pressure release - control system translate into a

drop in the productivity of pelleting lines and excess consumption of impelling energy by press motors. A number of actions could be taken to establish a normal situation:

- check that the length of the circuit between the pressure connection and the control valve is sufficient (> 1.5 m) to absorb the variations in pressure created by the pressure reducer (5 plants)
- check and repair/refurbish the electronic regulators on the pressure release control valves (5 plants)
- install an "all-or-nothing" block valve, upstream of the pressure release - control valve (1 plant).

5.3. Modulating valves and controlling the flow of steam

All the plants are equipped with a modulating valve driven by a controller and a temperature sensor. This sensor, which is installed at the conditioner outlet, enables opening of the modulating valve to be controlled on the basis of a temperature set point and the temperature of the meal-steam mix.

Two pelleting lines are equipped with a system that automatically cleans the control sensor. In the other cases, cleaning is carried out manually and there is often a significant layer of product deposited on the sensor, which increases its response time and may be the cause of a press stoppage.

Within the framework of audits, this sensor is systematically cleaned before starting the data acquisition period. In two cases, this procedure highlighted a significant difference between the temperatures measured by the control sensor and the measurements taken by Tecaliman using calibrated sensors.

Over part of the temperature measurement range, these plants underestimate the processing temperatures (from 10 to 16°C). The consequence of this measurement error may be significant in terms of the concentration of thermolabile elements in the feed (e.g. phytases). As testing progressed, a reduction in the processing temperature was observed in one plant. This change is primarily attributed to a drop in steam pressure, but it should also be noted that this phenomenon should have been compensated for by regulation of the modulating valve. The hypothesis of a drop in steam pressure combined with malfunctioning regulation of the modulating valve seems the most likely.

In conclusion, in order to optimise operation of the steam injection control system, plants must establish systematic procedures for cleaning and checking control sensors and monitoring the operation of their control system.

6. Pelleting press conditioners

6.1. Geometric characteristics and motor capacities

The majority of conditioners are cylindrical and have a shaft. On average, their length and diameter are 2 m and 0.48 m respectively. The conditioner's interior volume is more variable. It is between 188 and 971 litres, but 88% of conditioners have an interior volume of between 188 and 550 litres.

A single plant uses a large volume conditioner; this equipment has a volume of 971 litres and is equipped with 2 shafts.

The installed capacities of conditioners are between 11 and 18 kW. Although there is no significant correlation between installed capacity and interior volume, it is possible to see a tendency where the conditioners are grouped by volume class (Table 1).

Volume (litres)	Number of conditioners	Installed Capacity (kW)
188 to 350	10	13
350 to 550	5	15
632	1	18
971	1	18.5

Table 1

The load rates of conditioners is very low (24%) and there is no correlation between:

- the specific consumption of conditioners and that of pellet mills.
- the power consumed by conditioners and their filling level

Nevertheless, it is likely that inaccuracies in terms of the filling level mask this link.

In conclusion, conditioner motors are oversized. By taking the average specific consumption of conditioners and a safety margin in the event of an overload of 50% as the basis for calculation, installed capacities could be 0.6 kW/t, i.e. 6 kW for pellet mills producing 10 t of pellets/ hour, for example.

6.2. Blades

6.2.1. The geometric characteristics of blades

The length, width and number of blades per metre are relatively constant from one piece of equipment to another (Table 2).

	Average	Standard deviation
Length of blades (mm)	17.5	2.1
Width of blades (mm)	6.4	0.7
Number of blades per metre	17.9	3.7

Table 2

In general, blades are arranged to push the product from the intake to the outlet and their angle is between 20 and 40°. However, in some cases, lower angles (10 to 15°) or blades arranged to curb the product's throughput (angle of 302 or 350°) are observed. This setting is frequently based on data provided by the manufacturer, but in many case, there are no written documents.

6.2.2. Blade speed

Sixteen conditioners have a blade rotation speed of between 176 rpm and 466 rpm, which equate to peripheral speeds of 3.9 to 10.3 m/sec. These speeds lie within a range that matches bibliographic data and is the optimum range for creating the meal-steam mix.

One conditioner has a rotation speed of 142 rpm (3.2 m/sec). This speed is probably insufficient to create a homogeneous steam-meal mix, which translates into major variations in the power consumed by the press motor (C.V.% of 15.3%).

6.2.3. Wear

53 % of the conditioners have worn blades (wear from 5 to 30 mm). In the case of one plant, worn blades are associated with broken blades.

This wear is the cause of the formation of dead space in the conditioner and of deposits.

6.3. Injectors

An examination of the injectors for 16 conditioners reveals that 43.8% of facilities have partially clogged injectors. Under these conditions, the speed of the steam entering the conditioner is higher than that anticipated by the manufacturer, and the creation of a homogeneous meal-steam mix becomes uncertain.

6.4. Dead space and the presence of deposits

The thickness of deposits depends on the dead space. Dead space itself depends on several factors:

- the length of blades in relation to the diameter of the conditioner, which varies over time with wear (dead space between the blades and the wall of the conditioner)
- The width and setting angle of blades (dead space between the blades)

Consequently, the facilities with the greatest degree of wear on blades (5 conditioners) have deposit thicknesses and dead spaces above 20 mm and 17% respectively, and another conditioner has blades that are too short.

The layer of deposits generally has a rippled form, with the hollows created by the passage of blades. The formation of these ripples is due to the fact that the angles or width of blades are not large enough for the blade trajectories to overlap. The thickness of deposits is greater at the steam intake. The moisture of deposits is high (from 30 to 50%), and these conditions are favourable for the growth of bacteria in the conditioner during periods when the pelleting line is stopped and, above all, at weekends.

6.5. Average residence time in the conditioner

It was possible to measure the residence time in 8 conditioners, by injecting a tracer. On average, the residence time is 11.6 seconds, but the dispersion of this figure is high (standard deviation of 4.1). The population studied is insufficient to

determine the influence of the speed and angle of blades on this figure.

These residence times are above those appearing in the technical literature, but it is likely that, in these documents, the term "residence time" equates to "transit time".

6.6. Filling level and transit time

These figures are systematically calculated, but their use is rendered impossible by the inaccuracy of data used to perform these calculations. In effect, filling level and residence time are calculated on the basis of the press speed and the quantity of product present in the loaded conditioner. However, this data is marred by errors.

Nevertheless, it is possible to calculate the filling level for conditioners based on the average residence time, the conditioner's volume flow and the conditioner's interior volume (Table 3). The quantity of data available is insufficient to reach a general conclusion regarding filling levels.

Conditioner	Average residence time (seconds)	Filling level (%)
a	22.2	35.4
c	14.0	25.2
d	15.3	39.9
f	9.6	3.5
g	7.9	7.4
h	6.5	4.3
i	5.8	7.4

Table 3

6.7. Conditioner performances

6.7.1. Conditioner efficiency

The inaccuracy of the method for estimating the press speed does not enable us to accurately calculate the mass of product entering the conditioner and, therefore, the conditioner's efficiency. However, in two plants, the data needed to calculate this efficiency has been recorded (speed/throughput, temperature and steam pressure).

In these plants, water use efficiency is estimated as 69% and 67% respectively, while watt-hour efficiency is 76% and 78% respectively.

The fact that energy efficiency is higher than water use efficiency is a general observation, already noted by TECALIMAN during previous tests. This difference can be explained by measurement errors or incorrect positioning of the sensor. It is also possible that an energy source has been omitted from the energy efficiency calculation. Perhaps the warming caused by the rotation of blades is not insignificant. Moreover, the energy given off by the die, by radiation and convection, has not been taken into account.

As regards the quantities of water and heat not absorbed by the meal, it is possible that they are expelled with the air contained in the conditioner or that some of them build up in the deposits present in the conditioner.

6.7.2. "Rise in temperature for each percentage of moisture contributed by the steam" ratio

On average, a contribution of 1 % moisture by the steam causes a rise in temperature of 16.3 °C. This value is similar to those appearing in the bibliography. The range of variation is between 11.5 and 20.6 °C / H%, with four extreme situations that may be due to:

- a heterogeneous mix and moisture measurement conducted on a sample that does not correspond with temperature measurement (the temperature is the result of an average calculated on the basis of several dozen seconds of recording, while the sample intended for measuring moisture is taken at a precise moment).
- the use of wet saturated steam, for values below 14°C for each percentage of moisture
- the use of high-pressure steam and, therefore, steam that is superheated following a pressure release, for values above 17°C for each percentage of moisture (plant j)

7. Conclusions

This study has enabled a diagnostic method, which applies to steam incorporation facilities used for pellet mills, to be developed. However, this method could be improved if a technique for the continuous measurement of press speeds was available (calculation of the conditioner's efficiency).

All 17 audits, conducted over the course of the program, reveal that the use of steam within pellet mills is not fully optimised and that, as a result, there is potential for energy savings relating to pellet mills:

saving impelling energy by increasing the steam incorporation rate in mixes before pelleting.

saving heat energy by improving the conditions for using steam

Efforts must focus on the condition of the conditioner and the steam distribution circuit. In effect, the majority of plants are affected by a malfunction of one or both of these.

The pressure release valve, the trap separators, the modulating valve, the controllers and the temperature sensor must be checked regularly and, if necessary, repaired/refurbished.

At the same time, the plants' maintenance departments, together with press operators, must improve the maintenance of conditioners by:

regularly opening the conditioners to clean and repair/refurbish them (replacing broken or worn blades, unclogging injectors)

cleaning the temperature-based control sensors each time the batch is changed

As the data collected over the course of the program reveals that the maintenance plans provided by industrial operators are not sufficiently frequent and are sparsely applied.

The frequency of weekly "inspection - cleaning" of the conditioner must be retained.

Given that there is little information available in the bibliography, an effort must also be made by conditioner manufacturers. They must define the optimum characteristics of a pelleting press conditioner: length, diameter, speed, blade width, length and angle, injector position and size, filling level, etc.