A Continuous Airless Dryer for Meat and Bone Meal

G.B. Schou
Meat Industry Research Institute of New Zealand
PO Box, 617, Hamilton, New Zealand

INTRODUCTION

The aim of this project is to research and develop the technology of airless drying of meal products from rendering processes in order to increase energy efficiency and product quality. Airless drying - replacing the air in a conventional dryer by an atmosphere of superheated steam - can reduce energy costs by improving heat and mass transfer and allowing better heat recovery from the dryer's exhaust (Butcher, 1993; Stubbing, 1993).

Conventional dryers waste heat because they depend on large volumes of hot air to evaporate water from the product being dried. The exit air stream contains the water's latent heat of vaporization, but the water vapour is so diluted with air that it can be difficult to recover the latent heat at a useful temperature.

Airless drying eliminates the use of hot air to remove moisture from materials being dried, thereby substantially reducing fuel consumption. Instead of air, superheated steam, generated from the moisture in the material, is used as the drying medium. This can be achieved at atmospheric pressure, so pressurized vessels are not required. In a well-insulated dryer, approximately 90% of the thermal energy used to dry the material can be recovered from the steam vented from the dryer. The recovered waste heat can be used for process water heating or evaporation, or the vapour can be compressed and its latent heat of vaporization recovered by superheating the steam in the dryer.

OPERATION OF THE MIRINZ AIRLESS DRYER

The dryer can operate with either steam or air as the drying medium. To operate the dryer with air, it is a simple matter of removing the pipe section connecting the cyclone to the heater box (refer Figure 1). In order to operate the dryer with steam, it is first necessary to purge the air in the dryer by filling it with low pressure steam from an auxiliary boiler. The time required to fill the dryer with steam was determined from the following equation:

$$x = \left(1 - e^{-\frac{\dot{V}}{V}\tau}\right) \tag{1}$$

where x = fraction of dryer volume filled with steam
$\dot{V}$ = volumetric flow rate of steam into dryer, m^3/s
V = volume of dryer, piping, and fittings, m^3
τ = time to fill dryer, s

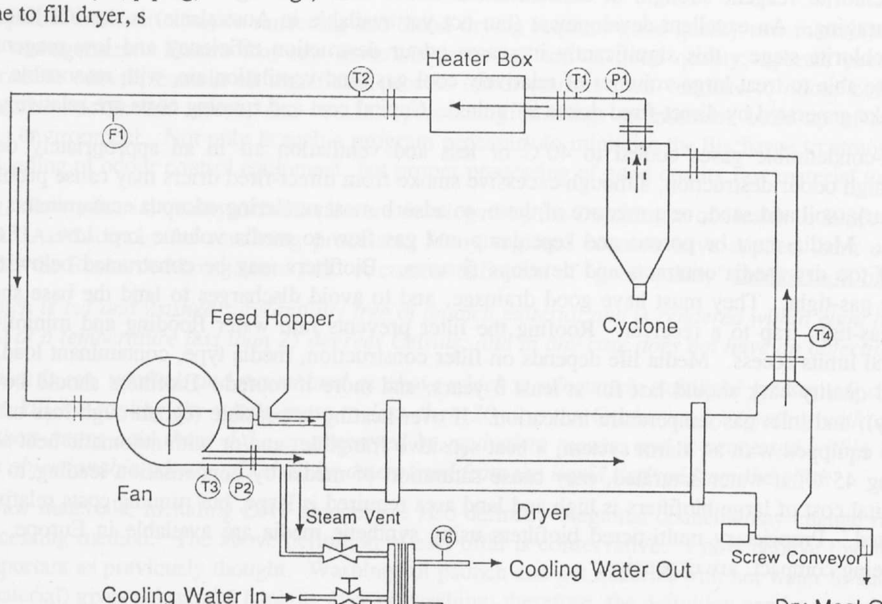

Figure 1.
Schematic of airless dryer.

The entire drying rig is lagged with 50 mm thick fibre-glass insulation to reduce heat losses to the ambient air. To obtain an estimate of the heat loss from the dryer, the system was first allowed to reach steady state with air as the circulating medium and without meal inside. (The heat loss from the dryer is essentially independent of whether steam or air is used as the drying medium because the controlling resistances to the heat loss are the thickness of the fibre-glass insulation and the natural convection coefficient around the outside of the drum). The heat loss from the dryer with either steam or air as the drying medium can be estimated using equation (2). T_3 and T_4 are the dryer inlet and outlet temperatures, respectively.

$$\dot{Q}_{loss} = 2.011 \times \frac{\left(\frac{T_3 + T_4}{2}\right) - T_{ambient}}{\left(\frac{199.5 + 182.0}{2}\right) - 18} \text{ kW} \qquad (2)$$

FLOW RATE AND TEMPERATURE MEASUREMENT

The air or steam flow rate in the dryer is measured with an EMCO TMP-700 turbine flow meter and the temperatures in the drying circuit are measured with type K thermocouples. All data were recorded by a Datataker® data logger that was interfaced with a computer so the data could be viewed graphically and in real time.

MEAL RESIDENCE TIME

The residence time of the meal inside the dryer is regulated by the rotational speed of the drum and its slope. The meal is also conveyed through the dryer by the co-current flow of steam or air, so to vary the meal residence time to any significant degree it is necessary to have the dryer on a negative slope (facing 'uphill'). (The slope of the dryer is set by two screw jacks mounted on each end of the frame that supports the dryer, and the slope is measured with a pivoting level fitted to the side of the dryer).

DRYING TRIALS TO DATE

Preliminary experiments were performed to dry meal continuously in superheated steam and in air. The dryer was able to successfully dry meal from a nominal wet basis moisture content of 50% to a moisture content of 10% or less. Batch drying trials were performed to determine drying rate data for meal dried in superheated steam and in air at various temperatures and for approximately the same Reynolds numbers. Figure 2 and 3 show the drying rate curves for meal dried in the two media at approximately 115°C and 180°C, respectively. At 115°C the drying rate is very much slower in superheated steam than in air, but as the temperature increases to 180°C, the drying rates in superheated steam are comparable to those in air. It has been shown in recent experiments with potato samples, that the drying rate is about 20% higher in superheated steam than in air, for a temperature of 215°C. More experiments are required at higher temperatures with meat meal to determine whether the same trend holds as for the potato samples.

The drying rate is very slow in superheated steam when the steam temperature is near it's saturation temperature at 1 atmosphere (100°C). As the degree of superheat increases, the drying rate becomes similar to that for air at the same temperature and Reynolds number. The thermal conductivity of the meal during drying is an important parameter that influences the drying rate. As the moisture content reduces, so to does the thermal conductivity of the meal and this reduces the heat transfer to the meal, which lowers the drying rate.

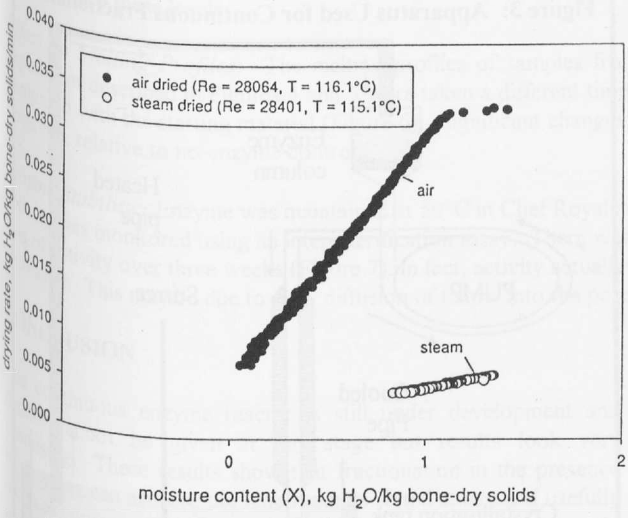

Figure 2.
Drying rate curves for meal dried in air and in superheated steam @ 115°C.

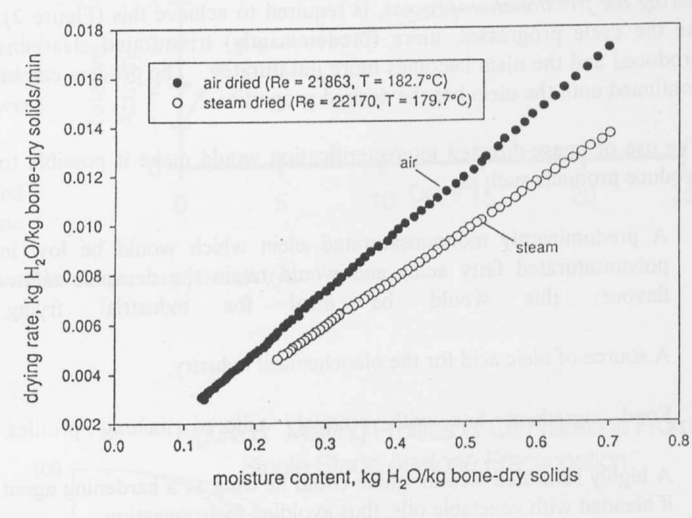

Figure 3.
Drying rate curves for meal dried in air and in superheated steam @ 180°C.

REFERENCES

Butcher, C. (1993) All steamed up, *Chemical Engineer (London)* 539, 16.

Stubbing, T.J. (1993) Airless drying: its invention, method and applications, *Chemical Engineering Research & Design* 71, 488-495.