Design Issues: Mechanical Dryers

1. Introduction:

There are three generic forms of mechanical dryer commonly found in use today. The vertical dryer, the horizontal dryer and the silo or stationary-bed dryer. These are batch dryers which naturally fit the batch pattern dictated by coffee processing, following, as it does, daily (or less frequent) harvesting. The first two stir the coffee during drying whereas silo dryers tend not to.

Generally, one can say there is no consensus as to which of these designs produces the best or most efficient drying. The following remarks apply to all three types of dryer:

- Pre-drying is required because the handling and drying requirements of fully wet coffee and substantially dry coffee (to 11-13% mc), whether cherry or parchment, cannot be accommodated in one piece of equipment;
- Control of the drying operation is exerted through controlling the moisture content of the entry coffee, the loading rate, inlet air temperature and the duration of the run;
- Drying at excessive temperatures generates black beans and reduces cup test quality. A grain temperature of about 45^{O}C is generally taken as the safe upper limit; and
- Evaporative cooling can be quite marked, and the temperature of the grain increases toward that of the drying air as it becomes dryer.

2. Main Features of Dryer Design:

- Capacity
- Airflow – rate of flow, counter/co- current
- Furnace type – temperatures, fuel source
- Type of fans
- Coffee mixing – not just rate – but also whether continuous or intermittent, maybe method (dead zones possible?)
- Gauges

3. Main 'Performance Criteria':

- Energy efficiency;
- Time to dryness; and
- Uniformity of drying.

4. Discussion of main Types of Driers in use in the Coffee Industry:

4.1. Vertical dryers

The typical vertical dryer operates as a strictly counter-current dryer with the grain moving downward against a stream of hot air that exits primarily at the top of the hopper. The grain moves through the hopper as it falls through a restricting funnel at the base and is returned to the top via a grain elevator.

Air temperature is regulated as input temperature by a thermometer inserted so that the air is measured as it enters the grain column and is controlled by balancing the mix of air between that from the heat exchanger and ambient air. Recommendations vary between 45 and 65^{O}C for the input air though some workers have reported satisfactory results using much higher temperatures.

Because the balance of residence time in the stream of air to that in the elevator is favourable over a wide range of batch sizes below the maximum load, vertical dryers can be used relatively efficiently over a greater range of loadings than is the case with the horizontal dryer.

Input moisture content is typically less than a 35% moisture content and full drying requires 15 to 24h.

Fig. 1: Vertical dryers: a. The flow-restricting funnel is a fixed orifice and the elevator runs at a fixed rate thus residence time in the drying column is fixed at a given load; b. Ambient and heated air is mixed at the input manifold and the input temperature is adjusted to the manufacturers recommendation; c. Both cubic and circular cross sections are available in this approach to drying; d. Dryers at exporters and large traders, as opposed to farmers, are of a different scale.

4.2. Horizontal dryers

The flow of air in the horizontal dryer is introduced along the axis of the grain chamber and is directed out along the length of it. The path is relatively short, a maximum of the chamber radius, and drying efficiency is sensitive to loading. Rotation speed is not normally adjustable so the control parameters for the operator comprise initial moisture content of the grain, loading (as near to design capacity as possible) and inlet temperature.

Input moisture content is typically less than 35% and the drying period is similar to that of vertical dryers – 15 to 24h.

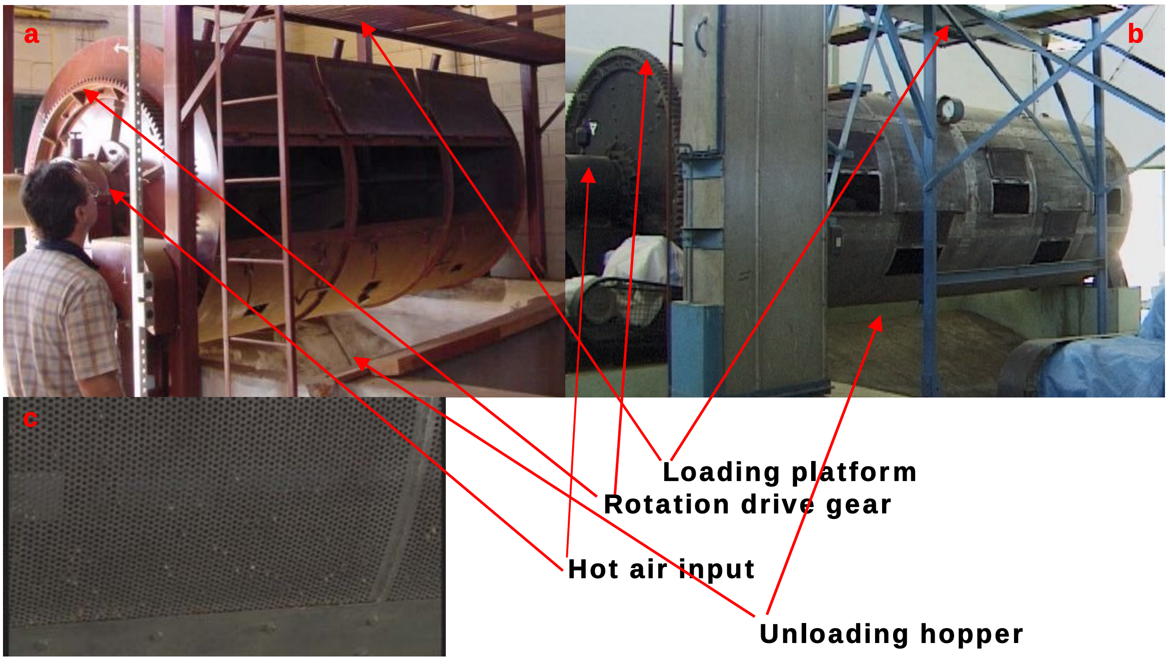

Fig. 2: Horizontal dryers: a. Small unit designed for the farm;
b. Large unit designed for exporters or very large estates;
c. Detail of the wall of the dryer showing the perforations through which the air exits - because the housing rotates, loading equipment is usually not fixed as with vertical dryers.

4.3. Silo Dryers

The silo or fixed bed dryer is well suited for parchment coffee and can be built with a minimum of technical input since the bulk of the fabric can be constructed in common building materials. The only moving part is the centrifugal fan and by combining pre-drying with final drying, the efficiency is good. A typical drying programme is as follows:

- Day 1: pre-dried coffee loaded into drying chamber in the afternoon and the furnace started; next batch of washed parchment is loaded onto ceiling;
- Day 2: furnace is closed down first thing in the morning; late afternoon dry coffee is removed from chamber and the pre-dried

coffee loaded through ceiling port; furnace fired up and next batch of washed parchment loaded for pre-drying.

Silo dryers have also been built in steel in cylindrical form with stirring devices. However, reports from farmers have suggested that damage to the coffee and non-uniform mixing often finds the mixing gear abandoned in the field.

Fig. 3: Silo dryers: a. Silo dryer with a solid fuel furnace. The chamber floor is a suspended perforated steel so that the space between the chamber floor and the building floor becomes the plenum chamber or inlet manifold;
b. Typically the bed thickness should not exceed 40cm - the loading port is just visible in the ceiling;
c. Parchment being loaded onto the roof of a silo dryer for pre-drying;
d. A silo dryer with a fuel oil furnace;
e. A small silo dryer designed for smallholders. However, the farmer reported this dryer lost heat out of the sides and was expensive to operate.