Design Issues: Pulping Equipment

In pulping equipment designed for coffee there are two traditional approaches: the disk pulper and the drum pulper, the latter of which can be oriented either vertically or horizontally

Recently a third design approach has emerged that has significantly different characteristics. In this equipment the cherries are fed through a slotted screen under pressure. either before or during pulping, and through which they proceed only if soft (i.e. ripe). This allows immature cherries (green or *verde*), which get crushed in traditional equipment and which cannot be separated by floatation, to pass through separately and unbroken. Another recent development is minimum water consumption systems.

In principle there is little to distinguish the two traditional systems from the standpoint of operational control. A pulper is evaluated with respect to capacity (kg of fresh cherries/h, for example), separation efficiency (the amount of skins and unpulped cherries found amongst the parchment) and damage to the product (frequency of 'nipped' and 'naked' beans). Other issues include power and water usage, durability and ease of maintenance and cleaning.

Capacity is a set function of the design and tends to be related to the number of discs or the size of the drum.

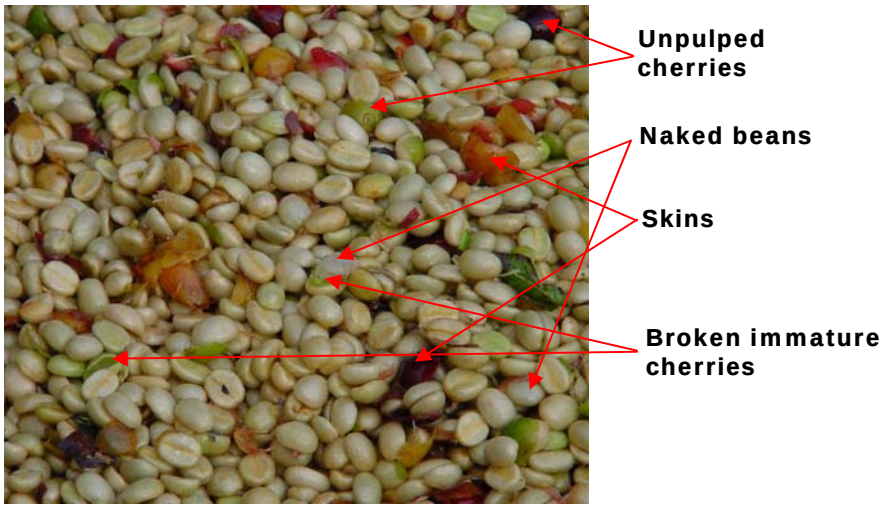
With a machine in operation, the quality of function is monitored by inspecting the output. The most common adjustment is in the tolerance between the disc or drum surface and the bar against which the cherries are opened. This can most clearly be seen in Fig. 1a (below) where the locking bolts of the lavender-coloured bars are clearly visible. Feed rate is usually a function of gravity, taking care of itself as long as the feed hopper is full. The rotation of the pulping surface, though theoretically adjustable, is normally run at the manufacturer's specification. In fact, poor pulping performance is usually due to poor quality input or worn pulping surfaces.

The drum of a drum pulper is covered with a perforated soft metal, traditionally copper and the dimples will become flattened and worn in time. Sticks or stones and, to some extent, green cherries will damage the surface. The surface of pulper discs is covered with a much finer rough surface which, when new, produces a distinct drag on a hand drawn across it. If worn smooth an increase in skins and unpulped beans will be noted.

Poor pulping performance will also occur if cherries of the wrong condition are fed into it. Immature, over mature partially dried cherries, badly infested coffee berry borer (CBB) cherries or cherries affected by coffee berry disease (CBD) will not be pulped efficiently. Immature cherries will be crushed since the parch has not separated from the mesocarp on one side nor the bean on the other. Dried cherries will tend to go through the pulper as whole cherries where they have shrunk significantly or as open cherries. Beans that have several galleries from the larvae of the CBB beetle are weak and often break to emerge as broken, naked beans. A pulped CBD cherry will retain a patch of skin stuck fast to the parch where the fungus has grown.

Fig. 1: Three current pulping systems: a. Disc pulper; b. Drum pulper which can be either horizontal or, as here, vertical; c. strip harvest pulping system omitting the lavador *which separates floating coffee.*

Fig. 2: A typical output from a pulping operation. It is said that a uniform product produces a better fermentation and a cleaner coffee.

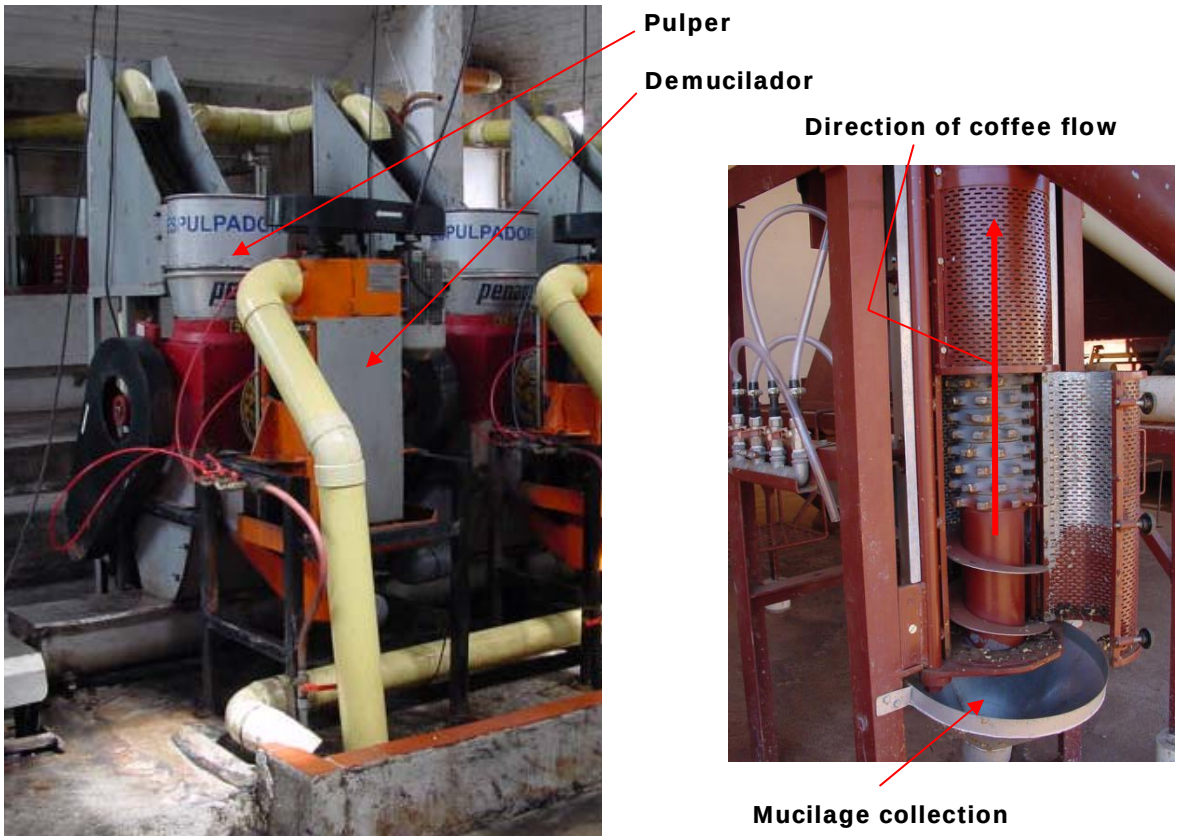


Water consumption is an issue in many producer countries both from the standpoint of water use and of pollution. Water demand for the wet processing of coffee is reported to be as high as $80m^3$/tonne of dry parchment (≈ 4.4 tonnes of fresh cherry). Of this about $25m^3$ is used in the pulping process alone.

Although unirrigated coffee can only be produced in areas where rainfall is above about 1000mm p.a., in many origins the harvesting (therefore processing) season coincides with the dry season, exacerbating the problem. Even without this consideration, running large quantities of water out of the aquifer (borehole water is the recommended source), through the plant and into the river is not effective use of a precious commodity. In addition, this effluent is acidic, and contains a high BOD load which will cause oxygen depletion in aquatic systems.

Developed in Colombia, the BECOLSUB (Beneficio Ecologicos Sub-productos) system provides water-free pulping and minimum water use direct mechanical washing. This system differs from the others in that water flow rather than tolerance between surfaces controls its effectiveness. Water flow set too low will result in higher than necessary shear, and the production of an excessive number of naked and broken beans. The frequency of naked and naked broken beans tends to be greater with this system than with traditional technologies.

Fig. 3: The BECOLSUB low water-use system.



The final design considerations relate to the stability of the fabrication material, cleaning/maintenance and operator safety. Fruit is generally naturally acidic. The coffee fruit or 'cherry' will begin to ferment in the field if not harvested and a proportion of fruit brought to the processing facility will be in this condition as an inevitable consequence of the uneven ripening that characterizes the crop. A pH of 4.5 to 5.0 can be expected during pulping. Unprotected ferrous metals and aluminium will oxidise in contact with coffee especially if the contact is allowed to persist from day to day, which will see a further reduction in pH to as low as 4.2, due to an inadequate cleaning regime.

As mentioned above, drum pulper surfaces have traditionally been made in copper and nylon can be found in some modern machines, especially BECOLSUB technology, but stainless steel, presumably due to cost, is rare. Rubber and plastic too, aside from pipe work, is rarely seen. Rubber has been used in the past and of course resists acid but it tends to become brittle over time and then break up into the product. Paint protects the sheet metal that comprises the housings of these machines but, of course, this is wears away. Unprotected, the sheet metal will rust and can break up into the product. Paint must be selected and applied with some care since it will rapidly flake off into the product if poorly chosen or applied.

Ease of access to all parts of the equipment that comes into contact with the coffee, especially coffee pulp and mucilage, should be an inherent design of this equipment. Installation should be such that the access is not compromised. Cleaning will reduce maintenance costs and failure rates since

degradation of the fabric of the equipment is accelerated by the acidity of the product, either in or out of active use.

One consideration of maintenance that does not change with the properties of the product is the lubrication of bearings and other moving parts. The design here should prevent contamination of product by lubricants during operation and should also facilitate removal, re-packing and reinstallation of bearings so that contamination of the product channels does not occur.

Fig. 4: a. Belt drives isolate the motor from water but unprotected belt drives provide a hazard to the operators; b. Corrosion of the steel sieve due to prolonged contact with coffee mucilage is clearly visible.

All of this equipment is powered by fairly powerful motors operating at fairly high speeds. Modern equipment is usually supplied with adequate guards around moving parts but installation often adds belts and pulleys which are not guarded. This can, and does, produce serious injuries to operators. Furthermore, during operation, guards are often removed. In some cases this is because the guards are poorly designed and interfere with normal operation. Careful thought is required from engineers taking into account how equipment will be installed and used in the field, and must consider the pressure to work at maximum capacity during the height of the season.

Special consideration regarding the electrical power supply and internal wiring of this equipment should be exercised. Water, often not very well controlled, is invariably required at some point in the pulping process – and usually in large quantities. Water is incompatible with electrical fittings. Often the answer to this is to place the motor remotely from the pulping mechanism using a belt drive to connect the two. Increasingly, more compact machines with more effectively channelled water are being built, but these still need to accommodate water spray during cleaning.