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The Modern Commercial Coffee Factory.
Some New/Old Ideas.
Processing for Quality, Efficiency and Sustainability.

The largely '3rd World' coffee plantation and processing industry is very conservative and factory designs still largely equate to the conditions of the 19th Century. So many factories still rely on the use of cheap unskilled labour to move product. They require extraordinary areas of land for drying areas and wastes treatment and disposal. They prefer to be built on a slope, to utilise gravity fed factory systems. The Management show little skills in the chemistry of fermentation and tend to rely on lots of clean cold water to solve all their problems, albeit creating as many more as they solve.

Today all those older kinds of solutions have steadily rising cost structures and new methods are required. A better understanding of the role of bacteria and other micro-organisms in the fermenting, washing, soaking and drying processes, indeed also in the preservation of quality in the polishing and packing of green coffee will allow coffee to be processed to a higher fraction of its potential quality in a fraction of the time, with less water, purchased electric power, and fuel for heating and drying.

The use of vertical tanks rather than large open troughs; using the roofs of buildings as the sun drying areas; bulk handing by pumps and blowers; with consequent reductions in floor area; allow factories to be built on small areas of flat land; operate from municipal water supplies; and be housed even in urban areas. Similarly, an update on the physics of mass transfer, and that of drying in particular, can make remarkable savings on energy costs.

Pumps are the Answer:

Nobody needs a heavy cast iron 'Kivu' pump these days. When people used 6 and 8 pole motors to drive them at slow speeds, they did a good job and did not damage beans. Coupled to a high speed 2 or 4 pole motor, the open faced impellor is sheer murder! Unless the impellor blades are set right up on the face plate everything is pulled into the corner by the water sliding back through the space, and beans are pressure rolled through the gap. They immediately jump back to their full size and one might wonder how they got through such a narrow slot, excepting that they are now minus their parchment coating. Skinned beans are a major source of 'Quality'problems.

The modern 'Vortex' impellor,[1] preferably in a self priming configuration, does not damage beans and will accept soft solids up to 50mm in diameter without damage to either the pump or the substance in passage. For a small village factory, a portable 50mm. alloy 'trash' pump close coupled to a small petrol or diesel motor will revolutionise the factory. [2] These pumps are made by Honda, Suzuki, Robin, Yanmar, Yamaha and a host of smaller companies and as a widely produced item have all the economies of mass production and scale. Just as long as they are flushed out with clean water every night, and are cleaned and sprayed with some rust preventive aerosol before being put away for the off season the alloy pump casting will last as long as the petrol engine will. Throughout Asia and India, every small town has its repair company who specialise in motor cycles and such small engines. Having a portable pump that can be carried home and locked up in a shed every night is a major security against the all too prevalent thieving that is a factor of life in the 3rdWorld.

For areas with electricity available , the half horsepower portable submersible sewage pump comes at half the price of the above, and will lift coffee 3 to 4 metres without difficulty. This is a typical example but there are many others suitable [3] For larger factories it is the 2-3hp portable electric submersible sewage pump, made in cast iron and resistant to anything that one can throw at it, that is the best choice. [4] One size fits all, and it will take the throughput of a factory handling up to 200 tonnes of cherry a day.[5] Costing around US$1,500 they are cheaper, more reliable and easier to handle in every way than the classical coffee pumps. The

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[1] http://www.esscopumps.com/vortexpumps/vortexpumpindex.htm
[2] http://www.hondapowerequipment.com/products/models.aspx?page=models&section=P2WP&category=gp
[3] http://www.grainger.com/Grainger/LITTLE-GIANT-Submersible-Sewage-Pump-4NY90?Pid=search
[4] http://www.grainger.com/Grainger/ZOELLER-Submersible-Sewage-Pump-4NW28?Pid=search
[5] http://www.grainger.com/Grainger/ecatalog/N-/No-80/Ntt-submersible+sewage+pumps+large?typeaheadSearch.x=16&typeaheadSearch.y=9

savings in skinned beans etc. will pay for them in 3-4 years. Such a pump will easily handle a 50-50 mix of beans and water, can lift coffee to 15 metres and the intense turbulence around the beans with such a low water ratio, is the best washing system there is.

For pulping drying, hulling and grading, the old European technology in cast iron has long given way to South American machinery in light sheet metal and alloy. Penagos from Columbia and Pinhalense in Brazil are the leading brands but there are plenty of others. Maybe this kind of machinery will not last as long as John Gordon, Kaack and McKinnon , but present day innovations in biotechnology, and efficiency will still out strip the life of mild steel and alloy and keep requiring new and better upgraded machinery to an ever reducing time scale.

Vertical Tanks:

It was technology from Australia, the Walkamin Agricultural Research Station in the early 1980s, that brought in the use of vertical tanks. The light weight stainless steel water tanks, that are so prevalent in Asia, and the heavier plastic varieties in other parts of the world, have made coffee factories portable and cashable! Banks are not happy to loan money on 'insitu' concrete that they cannot reposses, but lightweight tanks can be bought and sold, upgraded for size as the industry expands, and are hockable at the local bank.

A vertical tank on a stand, with a conical bottom, can be back washed by pumping water into the bottom and lifting the fermented mucilage up through the top and discharging it as a thick rather than a thin solution. This mode is very economical on water usage and allows the clean mucilage to be processed as a byproduct rather than just being discarded. A flat bottomed plastic tank can still be used by tilting it over on a sloping floor so that everything runs out the bottom drain hole at the lowest point.

The basic Machinery:

The most recent innovation in conventional processing machinery is the 'Environmental' pulper. Penagos [6] and Pinhalense [7] are the main brands. While the cherries are moved from temporary storage washed and sorted by water, that water is removed as they pass through the pulper and the pulp is separated without having its soluble sugars, enzymes etc. leached from it. This makes it very easy to ferment and preserve pulp as acid silage. Such silage can be stored for months and processed off season for year round cash flow.

[6] http://www.penagos.com/internacional/index.php?option=com_virtuemart&Itemid=210&lang=en

[7] http://www.pinhalense.com.br/equip-i-eco.htm

The major advantage of new designs of pulping machinery however, is the massive reduction in the use of water and the ability to recycle that water which is used through the machines. The speed of fermentation is greatly enhanced by the number of fermenting bacteria available and the concentrations of enzymes that they can produce. Those numbers are controlled by the temperature of the pulping water and the level of sugars available. Environmental pulpers may reduce the level of sugars into each pass of the water for very good reasons, but recycling the water builds them up again and raises the temperature too. It doesn't matter how dark the water becomes coloured, or how thick and soupy it is, just as long as each fresh tank of pulpage is begun with a clean batch of water. By the time that that tank is full, the water will have soaked down through it and been recycled several times and it has evened out the temperature and enzyme levels from top to bottom of the tank. If the tanks are very large, then mechanically demucilating the coffee is preferable to having a tank go solid with mucilage starting to ferment through to acetone, that particular smell that is evidence of the oncoming of fruity flavour. By storing the demucilated coffee in a tank for only a few hours before washing it out the next morning, there is sufficient fermentation to clean out all the mucilage in the centre cut. It is the color of the centre cut, when it is exposed by the roasting process, that so many buyers use to assess the quality of their purchases. Demucilated coffee put straight into a drier is better than the old dry processing systems that it was meant to displace, but demucilated coffee left to drain and ferment for 3-4 hours will wash out whiter than the finest of wet processed coffees washed in pure clean cold water. Those enzymes are the best detergent ever, and the bacteria that make them don't like cold water!

Drying Wet Parchment:

Sun drying of coffee is recognised as giving the best quality green bean, but it is generally regarded as being highly labour intensive, particularly if it has to be covered and uncovered because of rain storms in wetter climates. The temptation is to pump it all into the dryer, and part of the advantage of flat bed driers is that the water automatically takes itself back to where it belongs, and then one just lights up the stove!

What is needed is an initial drying process that takes advantage of any sun that is available to bleach the silver skin, and yet gets the parchment skin dry as quickly as possible , to lift the silverskin off the bean surface and to develop the desirable blue green colour of the green bean. (Wilbeau) Although I have seen several good ideas and suggestions for a such a combination machine , one of them taking the place of the conventional roof on a coffee store, and keeping the product up out of the range of theft, I

have not seen one that is actually functional. This is, for me, is the greatest area of need for further development.

The major portion of the moisture to be removed from the inside of the beans, from the beginning of the black stages around 16% moisture up to the colour change from black to blue/green, needs to be withdrawn at a slow constant rate, as close as possible to that which moisture can move through out from the centre of the beans to the surface. This orchestrates the colour and the phase change, from a black water based emulsion to a green oil based one, that spells the finest quality.

Rather than single pass rotary driers that require heavy parts to hold a rotating drum up in the air, the basically American design of a counter current flow, and a tapered sweep augur machine is to be preferred, on the basis of both initial cost and ongoing fuel efficiency. There is nothing for wet coffee to bridge and hang up on, and cracked parchment and uneven drying is a non event.
Shivers gives the historical basis,[8] but there are lots of cheaper alternatives from Asia and Europe.

Storage and Conditioning:

Avoid the temptation to store coffee in outdoor metal silos! It only takes a few degrees of temperature difference Between day and night, caused by the sun on metal surfaces, to move moisture from the outside of the bin, and condense it on the inside of the bin and mould damage will be sure to result. The best option is inside placed square bins with open tops made of plywood with contiguous walls and internally braced with steel rods, which also give the ability to easily climb in and out of them.

Such bins can double as conditioning units by having 'coffee wire' bases, and by careful configuration of a pneumatic transport system, fans, piping and blowers can be put to double duty. Avoid the temptation to use plastic pipes for moving coffee by air, and make sure that all metal pipes and fittings are well earthed. The grain industry has always had problems with sparking and electrostatic effects caused by moving dry materials through non metallic materials that do not earth and neutralise electrostatic voltages. Dust explosions are avoidable! Many experts will tell you that pneumatic systems are dusty and noisy, and indeed they can be if not well designed, but the ability to rapidly readjust pipe lines to deliver or retrieve material from any machine or storage area, and send it on to another overtops all of its disadvantages. And the ability to extract all that dust from anywhere, cyclone it out of the air stream and then burn it as additional fuel is just an extra bonus on top!

[8] http://www.shivvers.com/circulator_ii_legacy.html

Quality Assessment:

A trained liquorer, or better still three of them to compare notes, may still be the best assessment of flavour and quality. However' Liquoring is a dying art. A reconditioned gas chromatograph, set up for coffee analysis and costing around $20,000 , as well as producing a printout of all the constituents which contribute to a coffee's acidity body and flavour , is an admissible document, minus any of the prejudices inherent in a subjective liquoring assessment.[9] Start looking from Fig 10 on this ref. The day is coming, when a GC printout will be demanded by the importers, for every batch of coffee, down to a single container, that is exported from any country. The salary for a qualified laboratory technician plus the capital cost is less than for one liquorer, let alone three!

Bulking up for transport:

Marketing coffee in Jute sacks is still good for boutique coffee shops who like to paper their walls with nicely printed sacks. And we do try to keep the Bangladeshi jute industry alive, even though empty sacks at their destination now tend to get burned rather than being recycled into carpet underlay and automotive upholstery backings. Perhaps the inevitable rise in prices for petroleum based plastics will bring back a new lease of life for an ailing industry. However, porous jute sacking and non hermetically sealed shipping containers are not the best way to transport a perishable product. At the least, coffee exporters should put sealable plastic liners inside their containers for shipment, and flush them with dry nitrogen or maybe carbon dioxide before sealing up the liner and closing the doors. The whole scenario of premature aging and loss of quality during transport and storage of green coffee is another area that is ripe for research and development. Rancidity, inert atmospherics, antioxidants and temperature effects are all terms which get little cognisance in the coffee industry.

Handling the Wastes:

A major problem facing industry in the developing world is that its colonial instigators made no allowance in those early days for leaving a mess! Coffee pulp wastes were often sent down the shute into the nearest stream, Surplus hulls were heaped up and burnt. Water was taken into the factory clean, and simply left the factory dirty! It might now be possible to comment, facetiously, "Those were the good old days!", but there is still so many ways that coffee wastes can be processed into value added products rather than still being simply discarded , albeit in more environmentally friendly ways than in the past.

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9 https://www.sigmaaldrich.com/Graphics/Supelco/objects/8600/8564.pdf

Being basically a tropical product, coffee has the added advantage that wastewater cleanup can be most economically handled with biological processes rather than all the temperate climate based mechanical solutions. The main factor however is to recycle ones processing water, not only for increase in fermentation and quality parchment, but also to make biogas production worth while. You cannot make biogas out of large volumes of cold, once through the factory and out to waste water. If you use more than 3-4 cubic metres (tonnes) of water per tonne of green coffee, then you have a problem in sustainable profitable waste water recyling.

Water Hyacinth, for example, may be classed as a terrible invasive weed, but its universal presence in the tropics, and its ability to double its numbers in 10-14 days makes it the most efficient way of stripping pollution out of wastewater and allowing it to be recycled in a biogas plant for energy and fertiliser at absolutely minimal cost. Excess hyacinth biomass makes more biogas than coffee does, and you can do it all the year round. As a tertiary treatment 'water polisher', water hyacinth is so good that if necessary a factory can run on its own recycled water, [10] buying in only what is required for makeup purposes!

Coffee wastes can be economically used as sources of food, feed, energy and chemicals which could add so much value to an industry which always seems to be working at the limits of profitability. The efficient combustion of hulls can make the industry self sufficient in energy; using husk as a raw substrate for biological chemicals; production of 'single cell protein' and pulp silage for animal feedstuffs; exotic mushrooms for local foodstuff, freeze dry them for high priced boutique exports; there are many potential opportunities. It may be a difficult task to rebuild an existing factory to cater for all of these possibilities, but it is not too difficult to plan a new development so as to add value to every raw material that comes into a Modern Coffee Factory!

The intention of this paper is to alert coffee management to the various inefficiencies of the present industry and indicate directions for new developments. It is not possible, in such a short diatribe, to even suggest a fraction of the solutions available. Nevertheless, to be forewarned is to be forearmed! If you want to know more, write to me. Its free!

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[10] M.Larner personal communication. P.N.G.