THE HEAT IS ON

A BASIC GUIDE TO BETTER UNDERSTANDING HEAT TRANSFER ON A DRUM ROASTER

As roasters, one of the most important things we are always trying to achieve is better control of the roasting process.

And, one aspect of this is better understanding Heat Transfer (HT).

Understanding HT involves grasping the mechanisms & factors that drive & control rates of HT during roasting.

Armed with such knowledge we can then determine how to modify & control roast profiles/ bean temps & roasting reactions accordingly.

So, let's get geeky for a bit!

Roasting is the transfer of heat over time &, due to Heat Transfer, is a series of carefully controlled chemical reactions & physical transformations of the green bean into something soluble and tasty.

Happy Days!

The application of heat in roasting determines how fast/slow coffee roasting reactions occur during roasting, affecting the nature of flavour, aroma & colour generated by those reactions, also depending on the rate of HT and duration of the roast.

Reaction rates of HT to and within the bean also affects how the bean temp changes during roasting, depending on reactant concentrations/ components of the green beans (ie: moisture, screen size, density etc.) & thermal properties of the beans.

Hence, overall, knowledge of the 'science' behind Heat Transfer is essential to helping us as roasters roast more knowledgeably & profitably.

CONDUCTION, CONVECTION & RADIATION - the 3 forms of Heat Transfer - are deceptively simple scientific concepts that, once better understood in a drum roaster, will allow us to efficiently control & create a more repeatable, consistent product.

CONDUCTION:

Conduction is the transfer of heat from direct contact between the molecules of a hotter substance to a cooler one - like when you're smelling the roasting beans in the trier & you tap the hot trier on your lips (or nose) burning them! This is conducted heat!

In drum roasters we have 3 potential sources of conducted heat - the drum, the faceplate and the beans.

DRUM/FACEPLATE TO BEAN ROASTING:

Controlling drum-to-bean conduction is all about preheat temps and controlling the heat transfer at the beginning of the roast in line with the appropriate batch size.

Preheat/starting temps represent stored energy – and we must always start a roast with the right amount of energy!

The higher the starting/preheat temp, the hotter the roaster, the more energy can be transferred via conduction. Preheating/starting consistently with the same amount of stored energy will allow you to roast more consistently thus producing a more consistent product.

For smaller batches, lower the starting/preheat temps if you wish to follow the same profile as when you are roasting a full batch. Less coffee requires less energy.

To match the full batch profile, use the turning point as a way to equalise or find the right starting/preheat temp. If the turning point of the smaller batch is higher than the full batch, then lower the starting/preheat temp to match accordingly next time – remember, with smaller batches, it is always easier to add energy than it is to take it away once your roast has begun.

CONVECTION:

Convection is the transfer of heat through currents or liquid or gas. In coffee roasting, the transferring substance is air & the receiving substance is the coffee bean.

There are 2 major types of convection - natural convection & forced convection.

Natural convection occurs as air heats up, causing density changes - as air gets hotter it gets lighter & rises, while denser, cooler air falls. This flow then allows heat to transfer through natural movement or buoyancy.

Forced Convection is heat transferred through currents that are moved by an outside force such as a pump or a fan. This is a quicker, more efficient method of heat transfer than natural convection.

In both drum and air roasters, forced convection is the major mode of heat transfer.

Air roasters force/blow air with positive pressure through the roasting chamber and drum roasters use negative pressure, sucking air through the roasting chamber.

The rate and ratio of convection in a drum roaster is directly affected by airflow and energy supplied by the burners. i.e: the higher the airflow and the higher the energy input from the burner, the faster the roast.

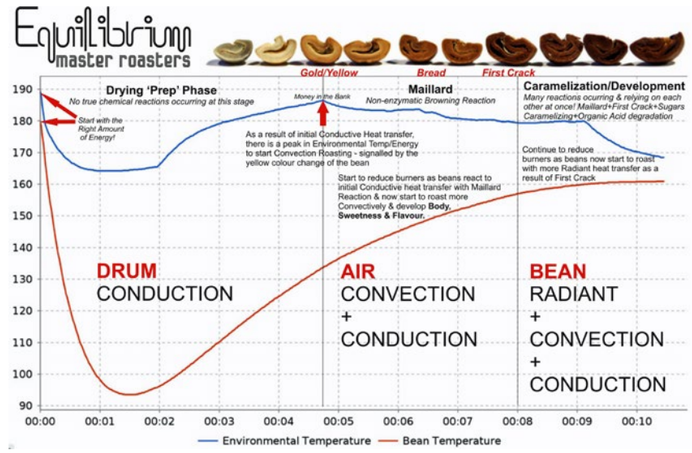
Hence, watching the Environmental (Exhaust) Temperature is imperative to making decisions on when to control the burners during a roast – especially at the end of the roast. If you don't have enough money in the bank or petrol in the tank, you can't go on holidays or finish your journey!

If you want to take away conductive heat by reducing the burners, you must have built up enough convective heat in the environment/ exhaust to be able to do this and be able to finish the rest of the roast on convective and radiant heat without the aid of the conductive heat from the burners.

RADIATION:

Throughout the majority of the roast the 2 sources of heat energy are the drum (conduction) and the air (convection). Just before first crack there is a 3rd source of energy - the beans themselves – Radiant.

As coffee approaches first crack it becomes exothermic and throws off heat/energy as it cracks. At this stage the roaster must control this release of energy by adjusting the burner down or off, increase airflow or both. This will manipulate the rate of convection (HT) in order to control the total energy (& overall profile of the roast) lessening the impact of the Radiant (bean-to-bean) energy of the exothermic beans.



BEAN MOVEMENT IN ROASTING DRUMS:

During roasting, it is also very important to consider that most of the beans lie in a tumbling pile near the bottom of the drum.

Spiral metal 'paddles' inside the drum are spaced accordingly to encourage a good blend/ mix of the beans from front to back along the drum's axis as it turns. This type of axial mixing increases uniformity of convective heat transfer & bean-bean heating.

And of course this heat transfer is also affected by the batch & screen size of the beans, size of the drum, drum speed, materials of the drum and design/spacing of the paddles.

HEAT TRANSFER IS ABOUT TOTAL ENERGY

DRUM, Air Bean
AIR, Drum, Bean
BEAN, Drum, Air

The above mantra and below picture represents the periods of the roast at which each type of heat transfer is at its most influential.

At the beginning of the roast it is about the stored, conductive energy in the DRUM - governed by the preheat/starting temp.

AIR or Convection becomes important for the heat transfer & formation of body, sweetness and flavour throughout the rest of the entire roast.

Toward the end of the roast the BEANS themselves become an important source of Radiant energy - & the dominant way heat is transferred.

At the end of the day coffee roasting is a dynamic process that constantly changes throughout the course of the roast.

As roasters, it is our job to gain a better understanding of each source of Heat Transfer, how they work and how to get the best results accordingly in relation to our own roasting system.

Next issue, I will tie everything together on Heat Transfer with specific roast development/ profiles & roast data/parameters that will set you on the path to achieving the sweet, sweet smell of roasting success - and maybe even a gold medal at Golden Bean!!

ABOUT THE AUTHOR

Anne has over 23yrs experience in coffee, having spent the last 10years roasting in both the USA & Australia at all levels from commercial to specialty. Anne is Head Judge for and has also won Golden Bean twice. Now consulting, with her company Equilibrium Master Roasters, roasters can engage Anne as a consultant or attend the monthly roasting course in Melbourne.

Email: aabflav@gmail.com
Instagram: roastresscoops