Heat Transfer in Coffee Roasters take place in 3 different ways :

1. Convection/Reflection (~70%) :
    - Hot coffee beans transferring their own heat to other beans by reflection is the heat transfer by convection.
    - Heat source has no direct contact with drum in hot air drum roasters. Hot air is generated in a separate heater, and heats the beans as it flows through. Surface temperature of the drum is low during roasting.
    - In hot air roasters, most of the heat is transferred by convection.

2. Conduction/Touching (~30%)
    - :Green coffee beans are first heated by conduction (direct contact) in direct heating drum roasters which transfer heat directly to the beans, i.e., heat reaches the beans as they contact hot drum walls.
    - Outer layer of drum is heated by burner while hot air inlets at the back of the drum allow hot air to contact with green coffee beans.
    - Coffee roaster’s inner temperature must reach to a certain temperature level which is preferably over 180 °C before roasting.
    - Right after beans are loaded into the drum, heat is transferred to the beans by conduction (touching) in the first minutes.
    - After beans are loaded, interior temperature level starts to drop. Most of the primary heat transfer is by convection.

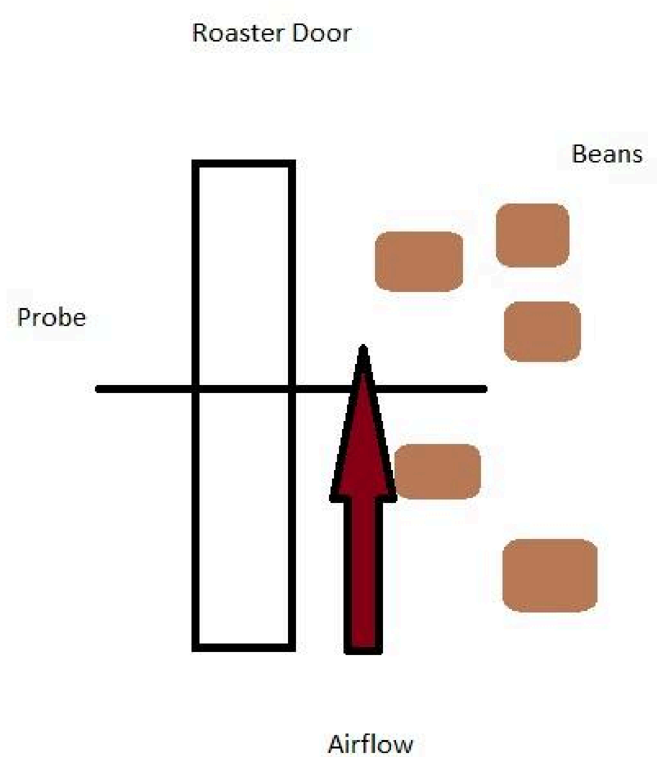
3. Radiation (Thought to be negligible) :
    - Radiation is the release of energy “via a process of electromagnetic radiation because of the vibrational and rotational movement of their molecules and atoms,” Candice explains. Probably the most well-known example of radiation is the heat of the sun traveling through the vacuum of space to heat our planet.
    - With current technology, radiative heat is difficult to measure and almost impossible to control in coffee roasting. Even roasters equipped with infrared burners are using infrared heat to heat a barrel (conduction) and air (convection), not directly applying radiative heat. Therefore, when it comes to radiation, it’s best just to acknowledge it’s there and leave it at that.

Heat Transfer and Moisture

During roasting, moisture inside the drum as well as the bean, affect the heat transfer.
After the first delay, moisture inside the drum increases the effect of heat transfer and accelerates moisture loss inside the bean.
However, the beans inner moisture has more complicated effects during roasting.
Three fundamental effects of high moisture levels to heat transfer are:
1. High moisture accelerates heat transfer as it increases heat conductivity,
2. High moisture increases the bean's heat intake (absorption) capacity, which causes bean to need more energy to be heated,
3. High moisture provides more vaporized moisture discharge from the bean by blocking heat transfer into the bean.
Moist beans should be exposed to higher heat while dry beans to lower, since moist beans certainly get heated slower than the dry ones.

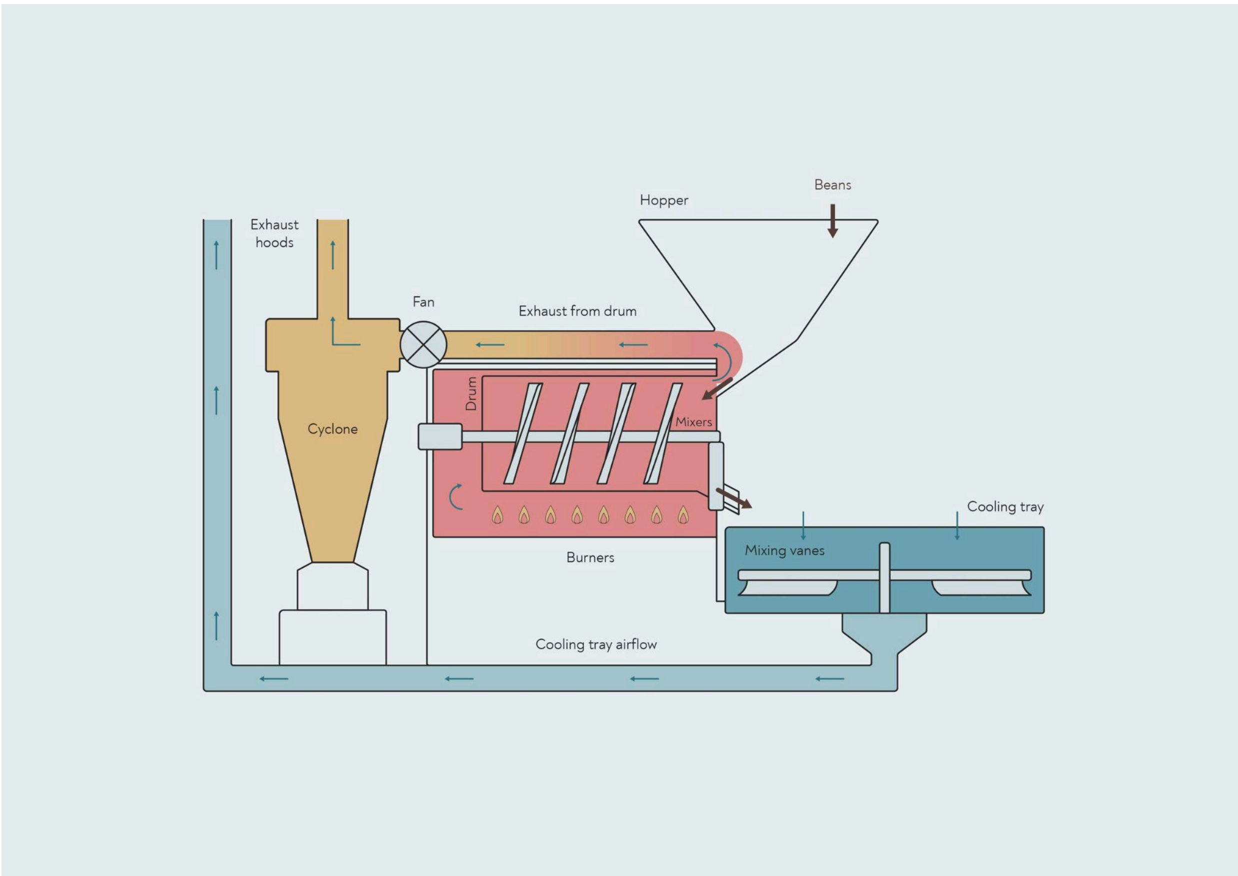
Changing the airflow changes a few things, the 2 biggest things we are experimenting and concerned with are:

- The ratio of convection heat transfer the beans undergo during the roasting process .
- The ratio of airflow the bean temperature probe experiences during the roast .



Negative Air Pressure Specs per Probat : -2 millibar

Airflow Diagram for Drum Roasters (Barista Hustle)



Experiment Outline

Roast The same coffee 3 times with different Negative Air Pressures to be controlled via the dampener on the airstack of the probat and to be measured with the electric manometer. All 3 coffees are to be cupped the next day and evaluated for insights.

Moisture and density readings to be measured and notated before roast.3,12lb batches of Colombia to be roasted as per the 12lb roast profile on Artisan for a medium drip.

Changing the airflow risks making changes to the readout of the temperature probe so it is up to the roaster to control the heat in any way he/she deems in order to keep the profiles as similar as possible with the ultimate goal of spending the same amounts of time in each 3 phases of the roast and ending at the same end temp.

Expected Outcome:

Given all thermal inputs and coffees to be the same we would expect the moisture of reading of the coffee to directly influence its cup quality depending on airflow in the roaster.

We will also make one general assumption, that an increase in airflow will result in a higher increase in heat exchange of energy to the coffee beans.

Assuming average ideal moisture content of 12%, if the measured green coffee is below 12%, we will expect better cup results with a lower airflow and overall heat transfer . If the measured green coffee moisture is above 12%, we will expect better cup results with higher airflow and heat transfer.

Complicating factors:

- Changing the airflow does change the airflow across the probe, making it literally read different numbers. Matching two profiles across two different airflows is sort of our only shot at matching the roasts, but they will be different.
- Increasing the airflow does increase convection heat transfer but also blows away the heat in the roaster and coffee beans faster, this makes assuming general relationships very difficult.