Infrared Roaster

Skywalker Roaster Key Characteristics and Behavior

There are two main peculiarities of this machine that must be clearly understood:

1. High Thermal Inertia — But Not From the Drum

This roaster has very high thermal inertia, comparable to a commercial drum machine — but for a different reason.

In a traditional drum roaster, inertia comes from the **thermal mass of the drum and structure**. In this machine, inertia comes primarily from the **infrared heating element (lamp)**.

The lamp does not respond instantly to power changes. Even after reducing power, it continues emitting significant radiant energy. As a result:

- Power changes have delayed effects.
- The rate of rise (RoR) reacts slowly.
- Large adjustments cause overshoot or collapse.

You are steering a *Titanic*, not a jetski.

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2. It Is NOT a Hot-Air (Convection-Dominant) Machine

Most small roasters operate thermodynamically like a body immersed in a hot convective environment.

This machine does not behave that way.

Heat transfer here is primarily **radiative**, not convective.

That means:

- The air is not the main heat carrier.
- The drum mass is not the main heat reservoir.
- The infrared radiation directly heats the beans.

This requires a completely different mindset compared to convection roasters.

Data and PID Control

Collecting roast data is absolutely useful but not for tight real-time PID control.

Trying to aggressively PID this machine is largely counterproductive because:

- The heater response is slow.
- Thermal inertia is high.
- The system overshoots easily.

Instead, use roast data to:

- Understand machine response characteristics.
- Plan future profiles carefully.
- Adjust timing, not constant power modulation.

This roaster prefers **few deliberate power changes**:

- 3–5 adjustments per roast are usually sufficient.
- The key variable is *when* to change power, not constant micro-adjustments.
- Heat step magnitude should be modest (5–10%), similar to gas drum roasters.

In contrast, on a convection roaster, you can sometimes maintain nearly constant power and achieve stable results.

Empty Machine Experiment

Setup

- Roaster run empty (no beans)
- Program: P11 (light natural roast preset)
- Preheat: 200°C
- Heater: 65%

- Fan: 65%

Automated Program Behavior

At 170–172°C:

- Heater reduced to 40%
- Fan increased to 90%

Without beans:

- Temperature plateaued at ~178°C (177–179°C oscillation)
- After 15 minutes, system timed out and entered cooling
- It could not exceed 179°C

Surprising Observation

During a real roast with beans:

- P11 cutoff temperature reaches ~194°C

Without beans:

- It cannot heat beyond ~179°C

This reveals something important.

It does **not** mean the beans are the primary heat source.
It means the beans are the **primary energy absorbers and thermal mass** in the system.

Corrected Physics Explanation

Radiation Dominates

The infrared lamp emits radiation. That radiation:

- Is absorbed efficiently by dark organic material (coffee beans)
- Is poorly absorbed by air (air is largely transparent to IR)
- Is partially reflected by shiny metals

- Is absorbed moderately by darker drum surfaces

This aligns with radiation physics and blackbody absorption principles. Dark, matte objects absorb radiation well.

On First Crack Temperature (~182°C)

The relatively low FC reading is likely due to:

- Probe placement near bean mass
- Radiant-dominant heat transfer
- Less superheated air compared to convection machines

It is not necessarily probe miscalibration.

This roaster’s temperature readings represent a different thermal environment than hot-air roasters.

Design Implications

If the drum were polished stainless steel:

- Radiation reflection would increase.
- Bean heating efficiency would decrease.
- The system would struggle more to heat.

A darker drum improves radiative absorption.

Practical Takeaways

- Use fewer, deliberate power changes
- Think in timing adjustments rather than constant PID modulation

- Expect delayed RoR response
- Understand that radiation is dominant
- Do not compare temperature numbers directly with hot-air machines

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Revision #1
Created 2025-02-20 12:00:56 UTC by Nirecue
Updated 2026-02-27 14:11:45 UTC by Nirecue