Coffee Roasting Optimization Focusing On Afterburner Performance and Energy Saving

- **Company Name:** Gas Brasiliano Distribuidora
  Natural Gas Distributor in Brazil

- **My Job:** Marketing and Customer Support

- Coffee Roasting
- Process Optimization

AGENDA

- Introducing the Coffee Roasting Process
- Objective, Motivation and Methodology for this Research
- Measures for Saving Energy in the Afterburner Process
- Measures for Saving Energy in the Roasting Process
- Conclusions

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PRODUCERS AND CONSUMERS OF COFFEE IN THE WORLD

TOP 5 - PRODUCERS

1. **Brazil**
2. **Vietnam**
3. **Indonesia**
4. **Colombia**
5. **Ethiopia**

TOP 5 - PER CAPITA CONSUMERS

1. **Netherlands**
2. **Finland**
3. **Sweden**
4. **Denmark**
5. **Germany**

Source:
Brazilian Coffee Association

- **Roasting is a heat process that brings out the aroma and flavor that is locked inside the green coffee beans.**

- **There are hundreds of flavors and aromas that can be extracted from the coffee bean, depending on the temperature and the time the bean is exposed to the hot air flow.**

Green Coffee

Roasting Process (Heat)

Natural Gas

Roasted Coffee

3 PHASES:

- **Drying phase:** which aims to eliminate moisture inside the bean.

- **Pyrolysis phase:** when coffee beans develop their specific aromas and flavors.

- **Cooling phase:** when water is sprayed on the beans, interrupting the temperature increase, in order to reach the desired degree of roasting.

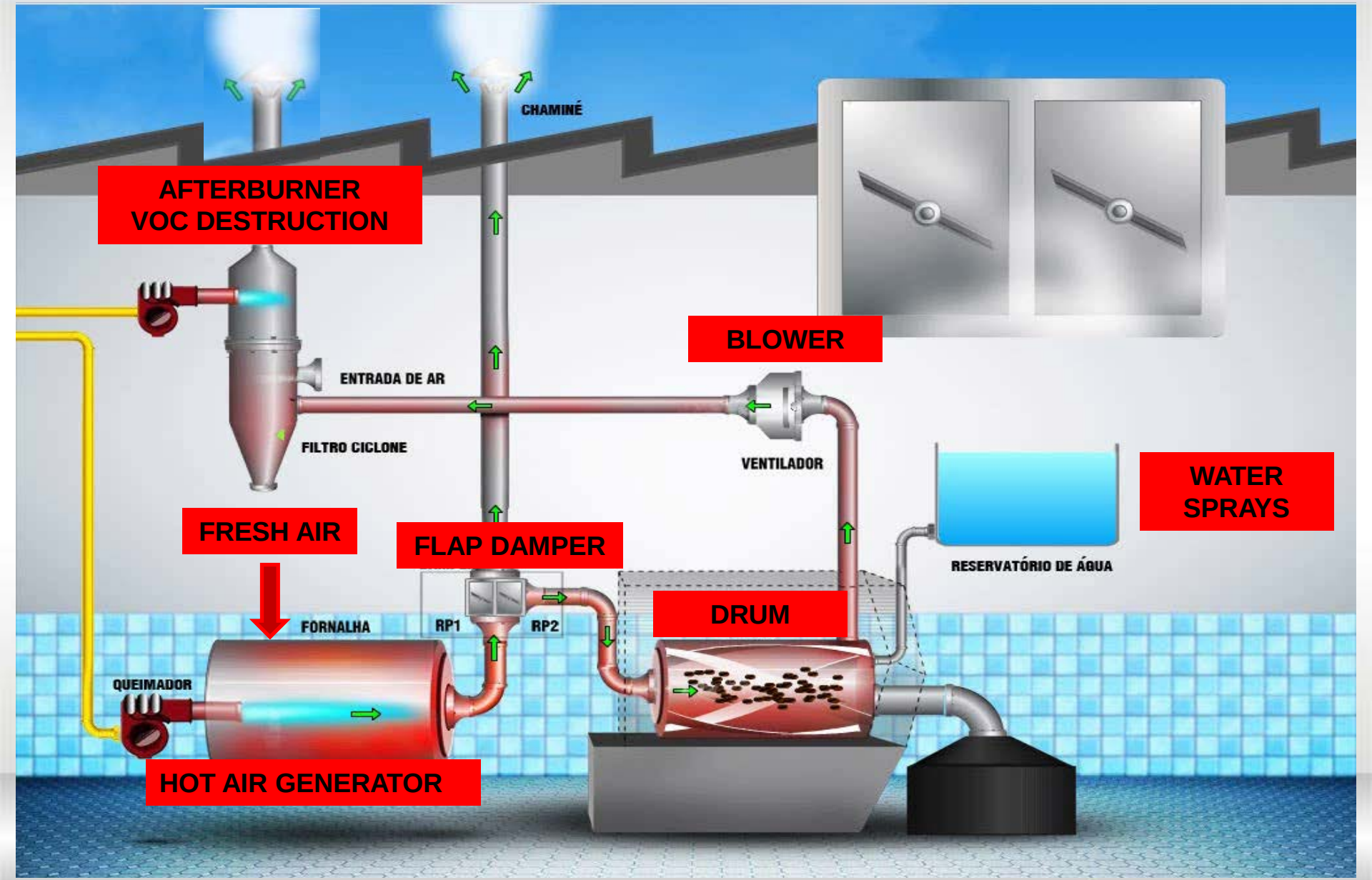
BEANS EMISSIONS

VOC EMISSION
ODOR

REGULATION

INCINERATION

COFFEE ROASTING SCHEMATIC



OBJECTIVE: **This technical research aims to publicize the details of the coffee roasting process, highlighting the <u>afterburner stage.</u>**

MOTIVATION:

- Nearly 70% of heat input to the roaster leaves through the chimney;

- The lack of information on how optimize the energy usage in coffee roasters in my country.

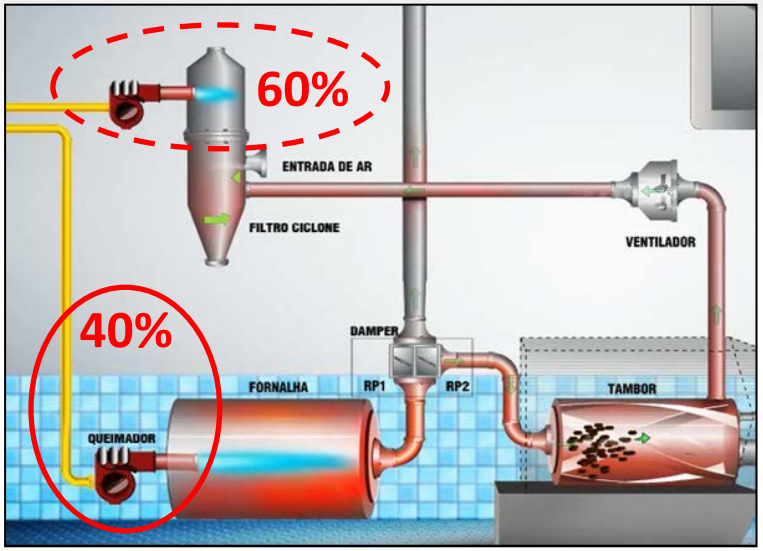
METHODOLOGY:

- **Consultation with manufacturers of coffee roasting equipment and their advice for energy saving measures.**

- **Case study - implementation of energy saving measures whenever possible or calculate the potential gains.**

- **Creation of an energy saving rank.**

CATALYTIC AFTERBURNER UTILISATION



Input Energy

The afterburner uses more energy than the roasting process itself:

There are two afterburner options:

A-) Thermal – VOC destruction at 700°C

B-) Catalytic – VOC destruction at <u>400°C</u>

→ **Catalytic converter with chemical reaction.**

Catalytic afterburner implementation:

- More costly solution
- Expectation of catalyst replacement: every 3 years

✓ 25% ENERGY CAN BE SAVED

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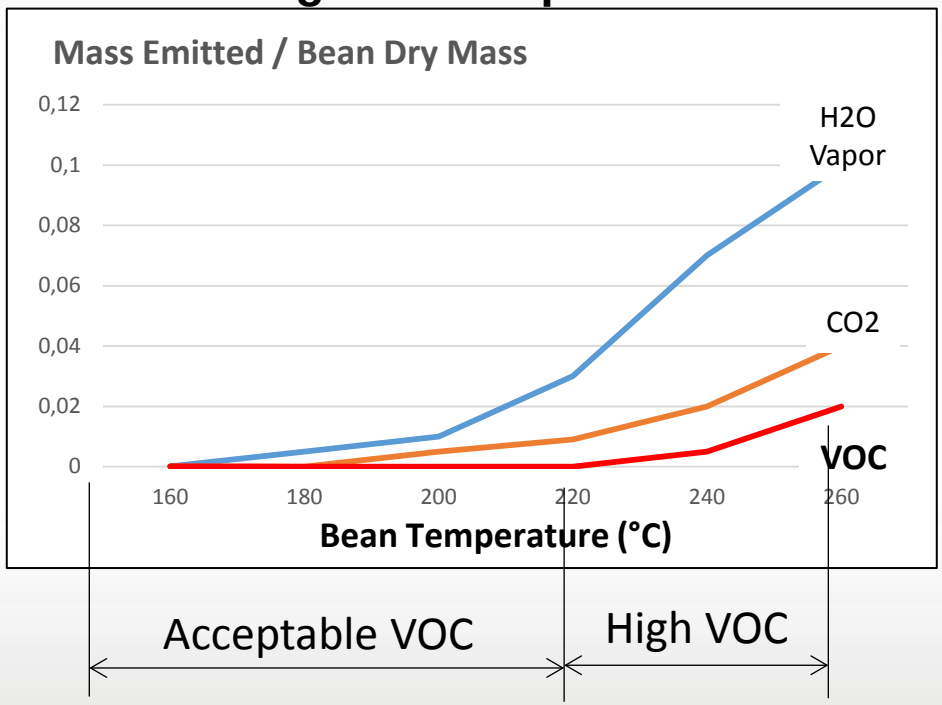
REDUCE AFTERBURNER POWER – ACCORDING TO VOC CURVE

Volatile Organic Compound - Curve



✓ 20% ENERGY CAN BE SAVED

- Beans released VOC only at temperatures above 225°C.

- Coffee producers in Brazil do not know this and keep the afterburner working full batch.

In order to optimize the afterburner operation, we can reduce the power when the VOC emissions are low.

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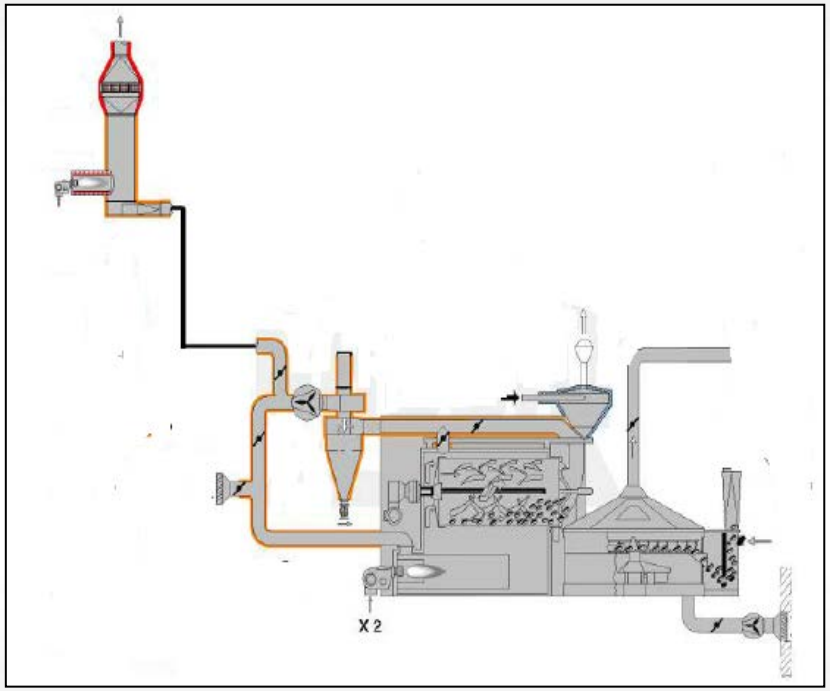
QUALITY IMPROVEMENT OF INSULATION



Replaced the furnace and ducting insulation

A thicker or high quality insulation can reduce the heat radiation from the roasting system to the environment.

✓ 4% ENERGY CAN BE SAVED

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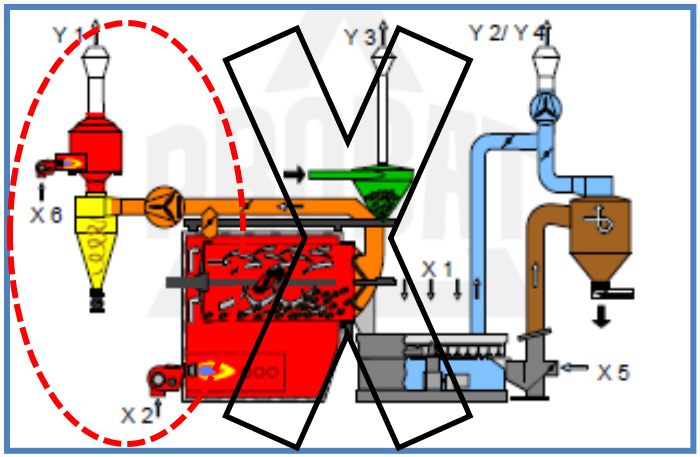
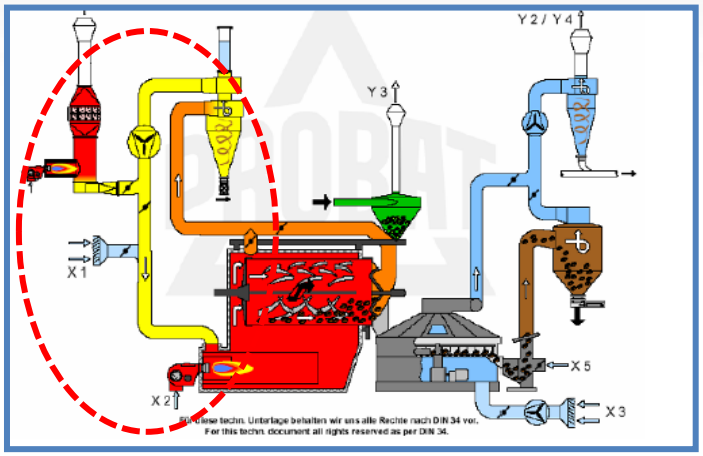
ROASTING EXHAUST GAS RECIRCULATION



No Recirculation (A)



With Recirculation (B)

- Configuration A: Should be avoided

- Configuration B: Recycling the exhaust gases while VOC emissions are low.

Lesser energy loss caused by exhaust gas heat.

✓ 30% ENERGY CAN BE SAVED

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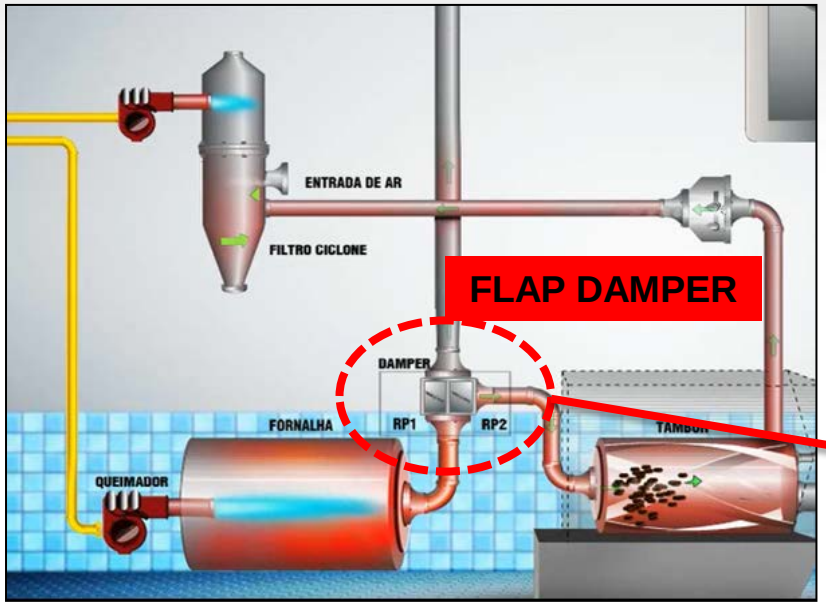
IMPROVE FLAP DAMPER RANGEABILITY



Bean temperature depends on:

- **Hot air flow**
- **Hot air pressure**

The flap damper plays crucial role in controlling the roasting parameters.

Flap damper replacement:

- **The previous flap damper: 2 positions**
- **The new flap damper: 4 positions**

✓ 7% ENERGY CAN BE SAVED

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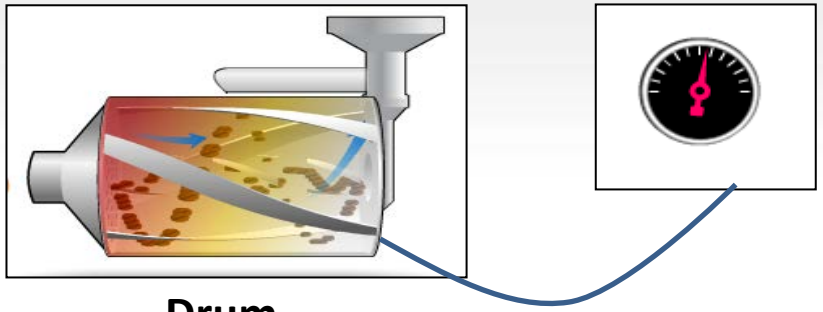
PROVIDING GREATER HOT AIR PRESSURE IN THE DRUM

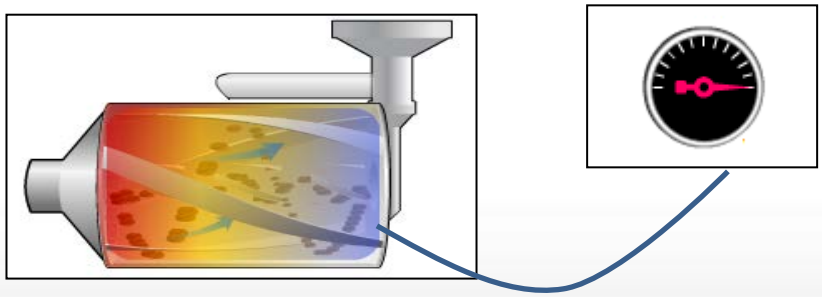
- ✓ **Drying phase is a less time-sensitive phase.**



Drum

Lower Hot Air Pressure

- ✓ **Increasing the hot air pressure in the drum during this phase, accelerate the time of water evaporation.**



Drum

Higher Hot Air Pressure

- ✓ **Significant reduction of batch roasting time.**

✓ 3% ENERGY CAN BE SAVED

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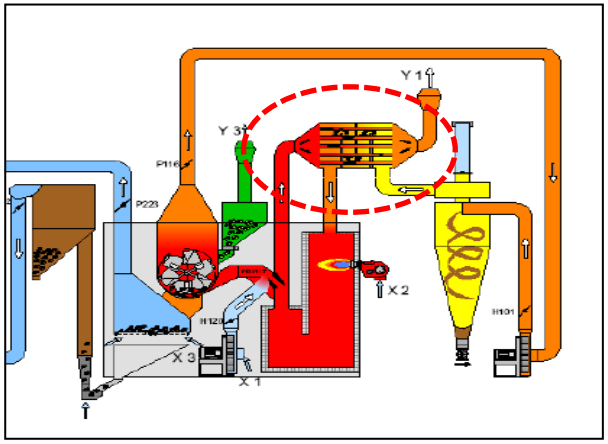
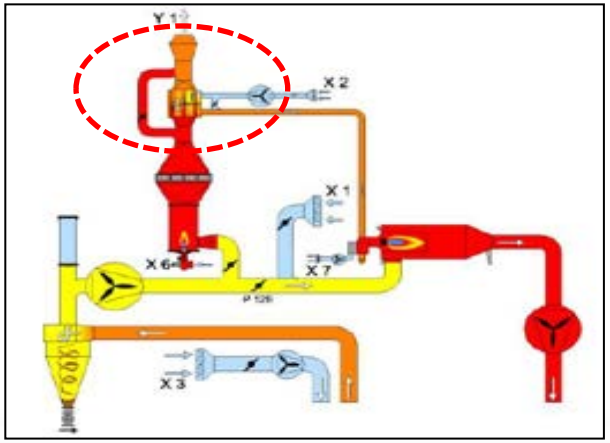
INSTALLATION OF THE HEAT EXCHANGER

Exploit the energy of the exhaust gases by using them to pre-heat the incoming process air: fresh air or combustion air.



Pre-heating fresh air (process cycle)

✓ 30% ENERGY CAN BE SAVED



Pre-heating primary combustion air (up to 250°C)

✓ 7% ENERGY CAN BE SAVED

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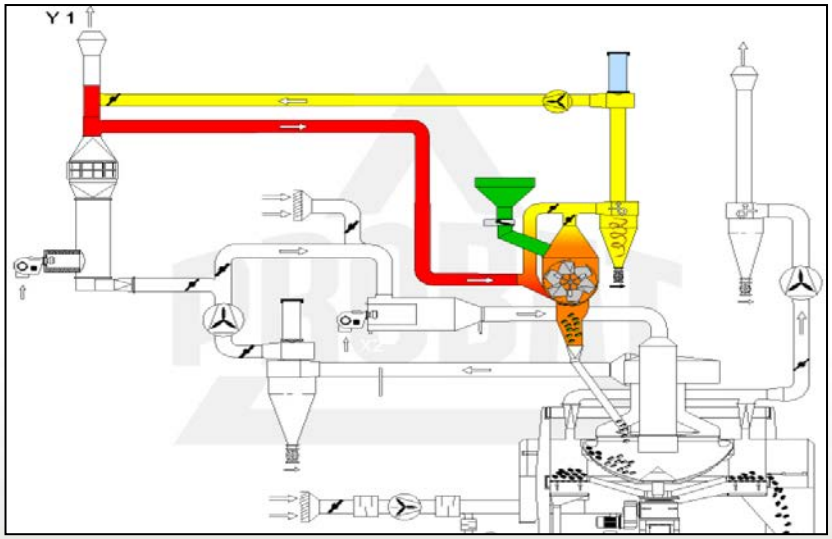
PRE-HEATING THE GREEN COFFEE BEAN

Exploit the energy of the exhaust gases by using them to pre-heat the green coffee bean before dropping them into drum.



Add a mixing chamber

Using cleaned exhaust gases from roaster

✓ 15% ENERGY CAN BE SAVED

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- In most cases, the incineration of VOC (volatile organic compounds) and odor in the afterburner result in an excessive use of energy.

- Some energy saving measures are available and must be studied in terms of technical and economic feasibility for each case.

Measure	*Energy Saving
Pre-heat the incoming fresh air (process air).	30%
Exhaust gas recirculation.	30%
Catalytic afterburning instead of thermic afterburning.	25%
Reduce burner power when VOC levels are acceptably low.	20%
Pre-heat green coffee bean before dropping them into the drum.	15%
Pre-heat primary air combustion.	7%
Optimization of roasting parameters (trials).	7%
Improvement of insulation quality.	4%
Provide greater hot air pressure in the chamber at drying phase (Reduction of batch time).	3%

ENERGY SAVING MEASURES RANKING

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THANK YOU

FOR YOUR ATTENTION !!