Blowing SMOKE

WAYS TO CLEAN UP, REDUCE AND RECIRCULATE ROASTER EMISSIONS

BY JOACHIM EICHNER
AND VISHWA ADLURI

MOST OF US WHO ROAST, cup and market coffee do so because we love coffee. But in the heat of passion, one should remember that coffee roasting is a business as well. This is true whether we're setting coffee prices, dealing with customers, or taking care of those nearly invisible but very important issues, such as emissions control.

Forethought about emission control prevents loss of friendly neighbors, guilty conscience and expensive penalties for non compliance. Dealing with emissions proactively is not only good for the environment, but also good for your business and, surprisingly, could be good for the quality of your coffee.

continued on page 26

WHY?

Having spent decades helping roasters reduce and eliminate emissions produced by coffee roasting, I realized that I really never checked into what penalties and fines could accrue from non-compliance to environmental standards. I'm not the only guilty one here—many roasters also do not know the emissions regulations in their area, or the penalties they could be charged. A perfect example is Oren Bloostein, president of Oren's Daily Roast, who I called to ask about these penalties. His answer—"I don't know, and I don't ever want to know"—contained a valuable lesson. It isn't that Bloostein doesn't care about having emissions control—he has an afterburner system, and is investing in a catalyzer system as well. For him, he is just less interested in knowing the amount of penalties and fines than he is in preventing putting emissions into the air.

There are three good reasons for roasters to address the emissions issue aggressively.

Make a Profit

To many of us in the business world, the economic considerations of emissions controls outweigh tree-hugging sentiments. But penny-wise economics is a short-sighted and ultimately expensive strategy for running a coffee-roasting business. Besides the penalties that Bloostein finds too gruesome to mention, there are several economic factors that speak out for compliance.

Over the past two decades, coffee has progressively brought together countries of origin, countries of coffee processing, and countries of consumption. You cannot order coffee in a successful café without naming an exotic country such as Kenya or Sumatra. Coffee drinkers, for the most part, care about the world and the environment. Savvy roasting businesses actually appeal to these green-hearted consumers to educate as well as make a profit. For these reasons, not only do I recommend strict emissions compliance, I urge coffee roasters to become environmentally responsible, and incorporate this sentiment into their entire business plan. This can only be profitable in the long term.

Love Your Mother

Besides being good for your business, emissions control is obviously good for the environment. Most scientists believe that human activity is impacting the environment in many ways, with climate changes being just one indicator. The emissions we put into the air *remain* there, and it is our responsibility to contaminate the environment as little as possible. Emissions contain a number of chemicals that could be detrimental to the atmosphere and those breathing it. My favorite argument for remaining compliant and being environmentally responsible is not economic, but being socially responsible, and to use a stronger word, ethical.

Love thy Neighbor

Just as parents find their noisy children entertaining while the rest of us pop Excedrin, so too with coffee aroma. Often, neighbors find this aroma offensive and the fumes a nuisance. Penalties are costly; therefore being nice and taking preventative steps—i.e. being polite to your neighbors is the best strategy. Irate neighbors will interfere in your business constantly, and this can only distract you from running a good business and roasting good coffee.

WHERE?

Currently, there are no federal requirements for afterburners. Title III of the Clean Air Act charges states with the responsibility of attaining clean air quality within their jurisdictions.

Since emissions standards are not the same everywhere, one could risk a guilty conscience by starting a roasting plant in a town where these compliance standards are low or in an area where emissions go undetected. To allay this guilty conscience, one could argue that they are not breaking the law.

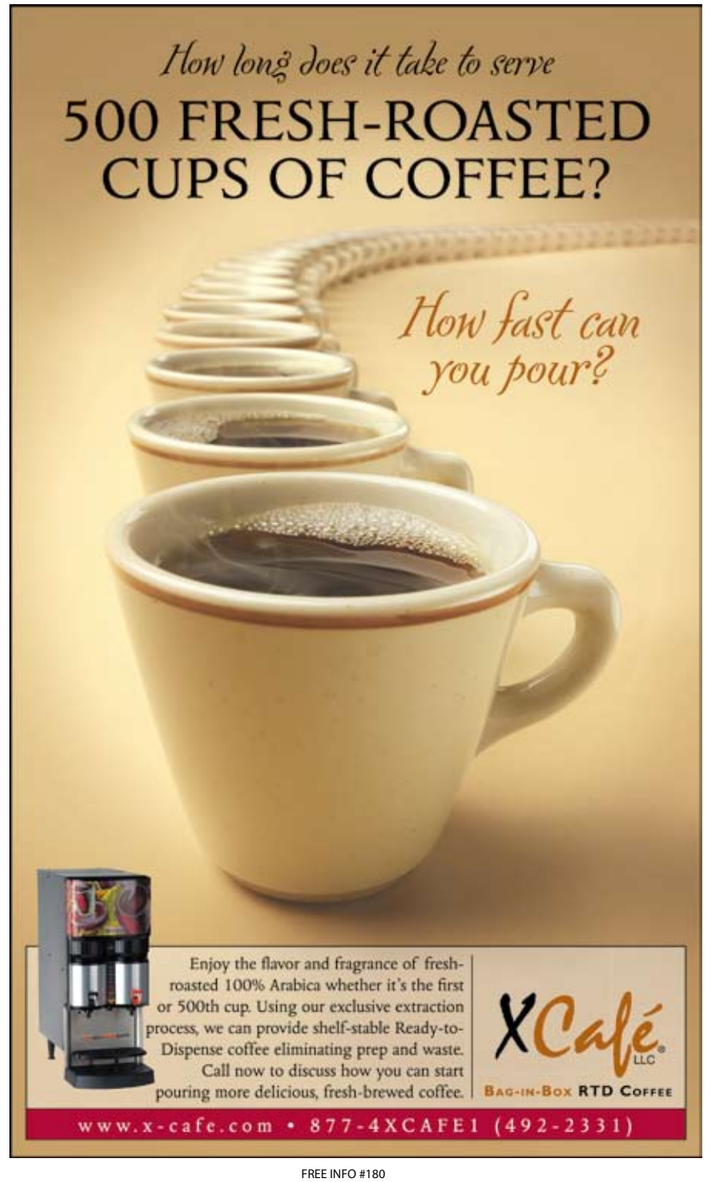
I've also heard the anti-Darwinian argument for such avoidance behavior: The cost of an afterburner will hurt smaller entrepreneurs. Again, my advice is not to say what people wish to hear, but what is good and right for the roaster to do. When writing a business plan, it's a good idea to include the cost of emissions control, just as one would include calculations for health insurance.

Furthermore, moving to a remote location often adds to fuel costs required to transport coffee for distribution. There are no guarantees that local emissions laws will remain unchanged forever. The slightest change in demographics of the plant location will lead to a re-evaluation of local emissions standards, so you could end up moving to the middle of nowhere, spending money to transport coffee, and eventually still face more stringent compliance requirements and associated costs.

How do you find out what the emission regulations are for your area? Begin your research locally by calling up your county. Many counties and boroughs have a town engineer on duty. You can also speak to other businesses in your area. Internet research is increasingly useful, as many government agencies are posting emissions standards online.

continued on page 28

FREE INFO #178



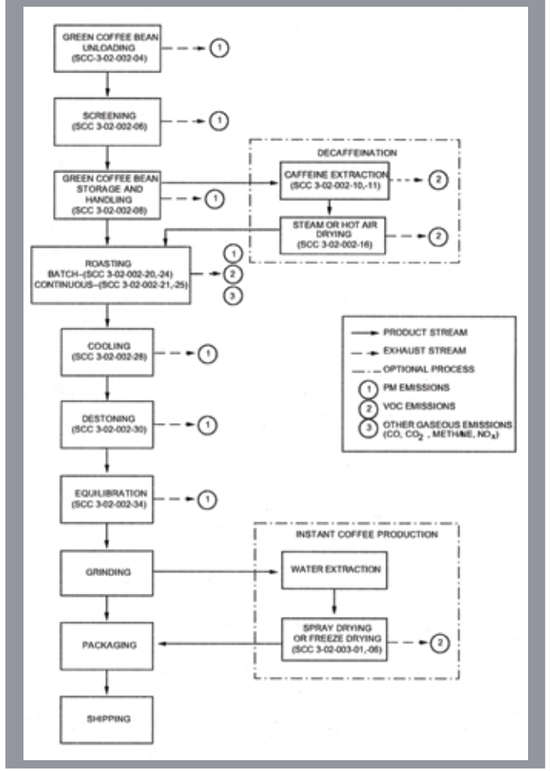
FREE INFO #180

FREE INFO #100

WHAT?

What exactly happens when coffee is processed? Coffee processing is a laborious and lengthy endeavor, of which roasting is the most significant but by no means the only emissions-producing phase. The following diagram shows a schematic of the various stages of coffee processing as well as the various emissions produced at each stage. The drawing shows both particulate matter emissions (PMs) and volatile organic compound emissions (VOC) at each stage of coffee processing. (The SCC numbers are legalese numbers, and can be ignored.)

Typical Coffee Roasting Operation



Once the coffee reaches the destination goal of perfection, it is quenched or directly discharged into the cooler. During the first phase of the cooling process, a lot of smoke is exhausted from the cooler stack until the roasted coffee is cooled to a level where the smoke emission stops. The amount of air exhausted from the cooler section is much greater than that from the roasting section. The cooler fan has a much higher capacity but a much lower static pressure than the roast fan. In some parts of the country, such as Washington state, it is required to have afterburners in the cooler exhaust line as well.

Let us now focus on the roasting process itself. Green coffee beans contain a wide variety of chemical compounds, including proteins, fats, sugars, dextrose, cellulose, caffeine and organic acids. When heat is applied to these beans during roasting, some of these compounds volatize, oxidize or decompose into toxic by-products of the roast. Unless roasters are connected to thermal or catalytic oxidizers, toxic compounds such as aldehydes (as formaldehydes), organic acids (as acetic acid), volatile organic compounds (VOCs, responsible for much of roast coffee's characteristic odor) and arcolein are then exhausted into the atmosphere.

Emissions can be subcategorized into two different types: gaseous and particulate matter. Suspended particulate matter is often visible as smoke. The clear bluish white gaseous emissions are caused by distilled oils and the breakdown of organic products.

Analysis of Coffee Roaster Exhaust Gases
(ppm = parts per cubic meter)

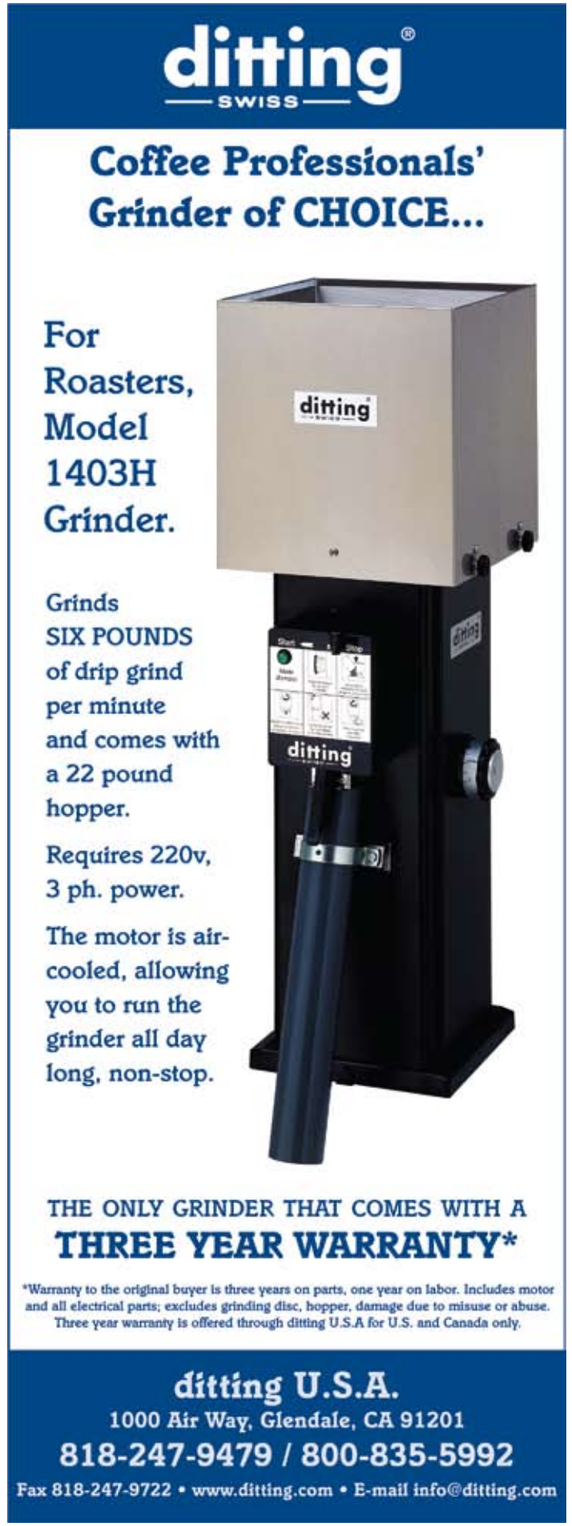
	Contaminant Concentration		
	Continuous Roaster		Batch Roaster
	Roaster	Cooler	
Particulate matter (grams per standard cubic foot)	0.189	0.006	0.160
Aldehydes (as formaldehyde), ppm	139	-	42
Organic acids (as acetic acid), ppm	223	-	175
Oxides of nitrogen (as NO_2), ppm	26.8	-	21.4

HOW?

Roasting, as well as quenching, cooling and destoning, all produce at least one of these emission types. Cyclones are typically used to catch particulate emissions, while afterburners or catalyzers are used to burn off suspended particles or smoke and toxic gasses.

The most commonly used pollution control device is the afterburner. Its working principle is very simple. An afterburner works by "burning off" (thermal oxidation) the air-contaminants. Exhaust air from the roaster is heated to a preset temperature (of about 1400° F) and maintained at that temperature for about 0.4 seconds. The exhaust air temperature from the roaster is around 400° F and needs to

continued on page 30



FREE INFO #126

be heated up. The afterburner will burn all volatile organic compounds (VOC) into carbon dioxide (CO_2) and water (H_2O), and will eliminate most, but not all odors. All visible smoke is eliminated. Thermal oxidation is EPA-approved and produces good clean results. On the downside, afterburners require a good amount of fuel to operate; also the high temperatures cause eventual wear and tear to the unit.

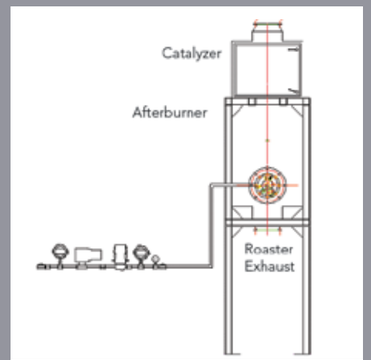
The second most common method of cleaning up the air is through catalyzer units. A catalyst is any substance that accelerates a reaction without itself being consumed in the process. For example, propane and carbon monoxide are oxidized as follows by a catalyst.

Propane + carbon monoxide + oxygen → carbon dioxide + water

$$C_3H_8 + CO + 6O_2 \text{ (catalyst)} \rightarrow 4CO_2 + 4H_2O$$

Exhaust gases from the roasting process are fed through the catalyst bed, which initiates and promotes oxidation of the combustible emissions, at temperatures in the range of 750–900° F. Once purchased, a catalyzer is cheaper to operate, because it operates on nearly half the temperature of an afterburner, and thus fuel costs are significantly lower. Catalyzers are also EPA approved. On the downside, catalyzers influence the airflow in a roaster by producing a differential back pressure.

Figure showing the relative positions of a burner, roaster exhaust, afterburner and a catalyzer.



There are two major types of catalyzers available: ceramic and metallic. The back pressure due to a metal catalyst bed is slightly lower than on a ceramic unit.

I am often asked by roastmasters about the effects of using a single catalyzer or afterburner for two or more roasters. Personally, I recommend using separate units for each roaster for a couple of reasons. First, there is always the risk that the one roaster is influencing the other when the emissions control device is not engineered accurately. This means that the roasting environment in the roaster changes due to smoke or increased pressure. Second, the roasting stage (e.g. quenching or charging) in one roaster can influence the roaster airflow in the other roaster. Again, with the same negative results.

Besides oxidation (afterburners and catalyzers) there are other ways of dealing with emissions. These are not as effective as oxidation, and are more difficult to deal with.

Of these, the first is dispersion. Dispersion does not actually eliminate emissions, but merely dilutes them beyond detection either by the eye or by the nose. A blower or a fan literally disperses the emissions. This is the equivalent of opening the car window while smoking.

Another device used in the industry is a scrubber. Scrubbers come in three different models: dry scrubbers, wet scrubbers and gas scrubbers. Wet scrubbers are the most common. These units wash the gases and pollutants out of the air in a modified spray chamber. The units are costly and require more maintenance than either afterburners or catalyzers. Instead of polluted air, you then have polluted water, which could be disposed of more discreetly. Jay Endres, president of the Roastery Development Group, had the ingenious idea of treating the resulting effluent in a microbiotic scrubbing system filled with live microorganisms that break down some of the pollutants.

It is also possible to use UV scanners, which remove smoke and odor from the exiting air. These units need lots of service, because the glass surface over the UV light has to be cleaned in short intervals.

None of these options is a common means of achieving compliance, especially in strictly regulated zones.

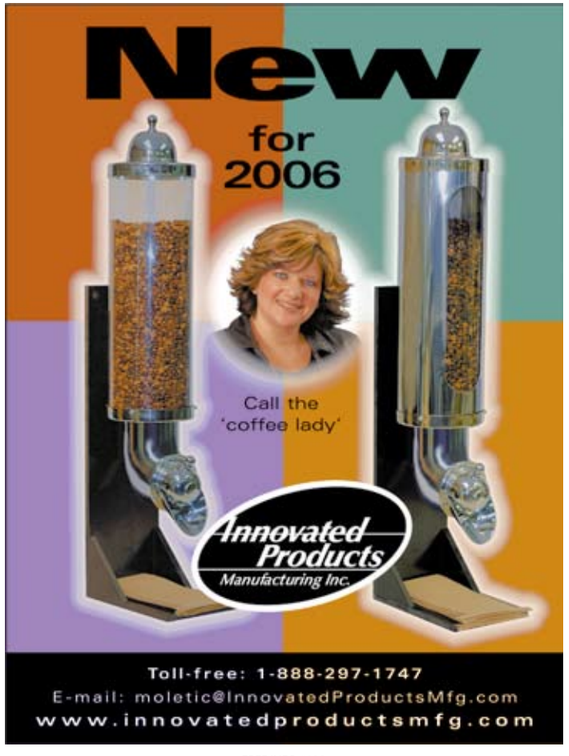
WHAT'S NOT HOT?

Burners. Most literature on emissions neglects to mention that the burner effluents from roasting produce nasty chemicals called nitrogen oxide compounds (NOX). Natural gas burners, as well as afterburners, also produce carbon dioxide as a byproduct, which may be more detrimental to the atmosphere than the original exhaust in the long run. Emissions can be greatly reduced by replacing an old inefficient gas-guzzling burner with a more fuel-efficient model that burns cleaner and provides energy more efficiently.

There is no way to eliminate burners altogether, obviously, because it is the source of thermal energy for the roasting process. In the past decade, however, burner technology has made many exciting advances. It is good for your budget and for the environment to talk to a specialist about the efficiency of your existing burners (both your roaster burner, and the one located

continued on page 32

FREE INFO #177



FREE INFO #138

FREE INFO #123

A roaster at Hawaii Coffee Company showing a recirculating system attached to the back of a 23R Jabez Burns roaster. The two bullet-shaped cyclones manage increased airflows.

in any afterburner you may be already using). A burner specialist will advise you on various fuel options and means to reduce NOXs.

I cannot overemphasize the importance of excellent burner controls in using burners sensibly. A good control system continuously and intelligently modulates the burner flame as needed by your roast profile. For example, energy can be saved by programming an afterburner to go on high fire a few minutes into a roast.

Depending upon the amount of coffee you roast, environment-friendly burner technology which includes an up-to-date burner and a good basic control system could recover its cost in gas savings.

WHAT ELSE?

Another way to reduce burner emissions (and save on fuel costs) is to apply thermal energy to roast coffee beans more efficiently. This is because temperature gradients within beans are less steep when higher gas flows and lower inlet temperatures and the same roasting times are used, than when higher temperature and lower gas flow rates are used. Rates of pollutant generation during roasting increase exponentially with temperature. Therefore, for beans with the same average temperature, beans having a steeper internal temperature gradient will generate more pollutants than beans with a lower temperature gradient.

Increasing airflows in roasters allows you to roast faster and at lower temperatures. A rough analogy of how this works is as follows: You can thaw frost-bitten hands faster by holding them under lukewarm running water than by holding them in front of a hotter lamp. The higher rate with which warm water is coming in contact with your cold hands allows it to deliver thermal energy more efficiently. In my experience, roasting at lower temperatures with higher airflows improves the taste of coffee by eliminating the flat and baked tastes produced by very long roast times.

Another option in improving airflow is to recirculate the air used in a roaster. Some EPAs recognize recirculating air through a roaster as method of reducing emissions. The EPA states, "Recirculating roasters have reduced emissions since they redirect a portion of the roaster exhaust back through the burners, resulting in the oxidation of some of the pollutants." Probat, Neuhaus Neotec and Scolari produce partial recirculating roasters.

You can also convert your roaster to a recirculating roaster. Recirculating roasters exhaust only one-third of the air as compared to regular roasters. Angelo Oricchio, president and CEO of Paramount Coffee, says "There are cost-effective ways to deal with emissions. By recirculating the air in my 23R Jabez Burns roaster, I not only reduce emissions, but I also reduce fuel costs. High airflows mean no buildup of oil and chaff on the walls of my roaster piping, I have not had to run any automatic clean outs (ACO) in the year and a half since I converted my roaster to recirculate. An ACO, which works like the self-cleaning cycle of an oven, uses a lot of fuel and downtime to heat all the pipes cherry-red to clean buildup from coffee oils and dust. In addition, my coffee tastes much better."

In Oricchio's recirculating system, one burner does double duty as both a roaster burner and an afterburner. Because this burner reaches the temperatures required for oxidizing emissions, you can roast and burn up emissions in one furnace.

CONCLUSION

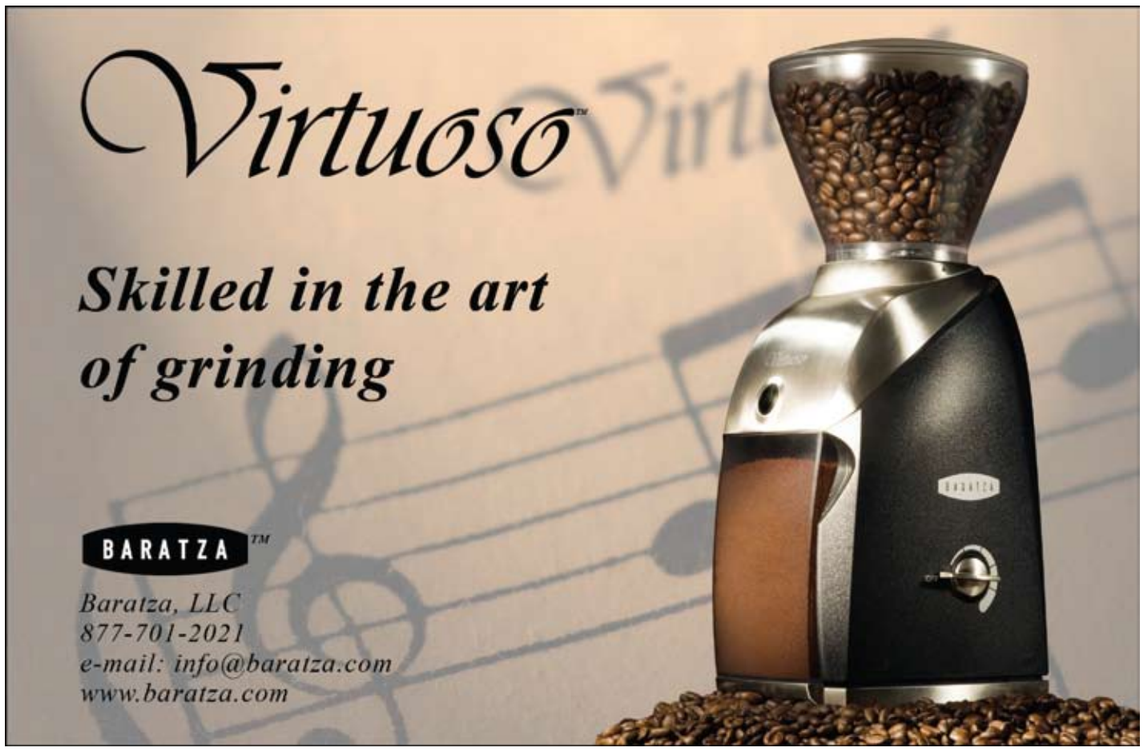
Emissions control is an important issue in coffee roasting. In an environmentally conscious industry where organic coffees are increasing their market share, unclean air is just not an option.

As Jim Wayman, president and CEO of Hawaii Coffee Company, says "I moved to Hawaii because it is a paradise. I have an afterburner, a catalyzer and my roaster is a recirculating system. Clean business is actually good business."

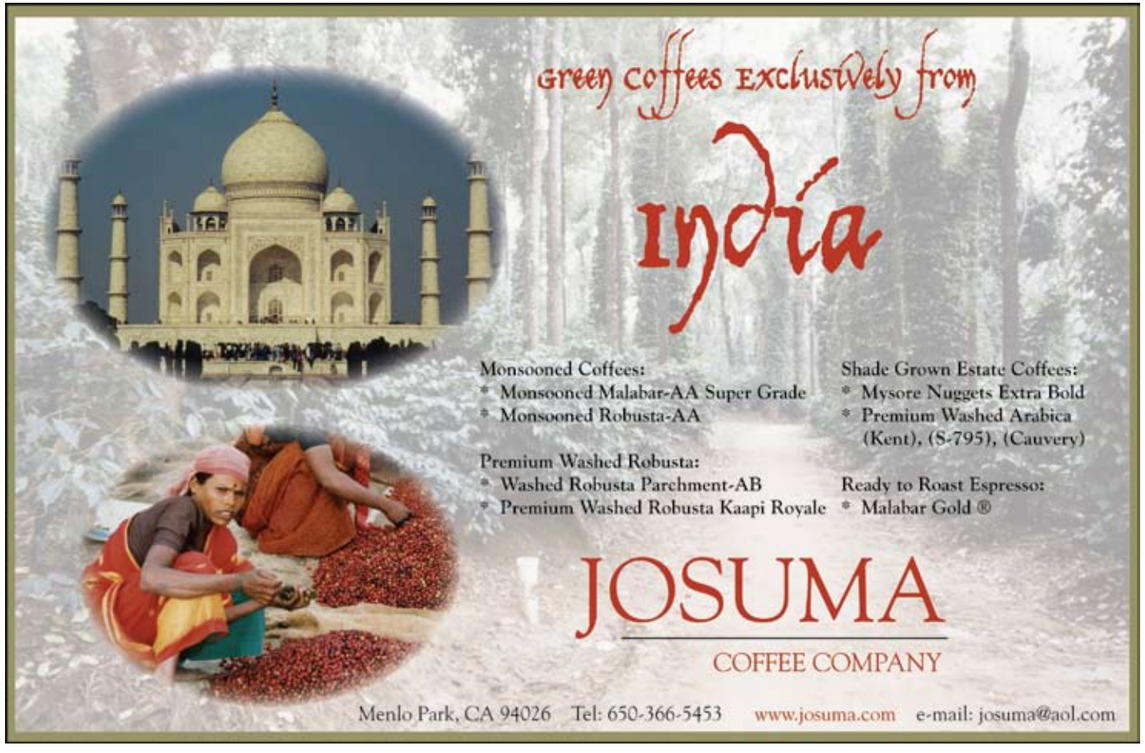
Emissions control does not need to be approached as an unexpected and superfluous headache. As long as you roast coffee, you will produce emissions as a natural byproduct. Even as you think about packaging your coffee to seal in freshness, you have to think about treating emissions. Just as you would not buy a car without proper exhausts, you should not operate a roaster that can cause damage to the environment, annoy your neighbors, endanger your own health and cost you money.

JOACHIM EICHNER is chief engineer at Praxis International, Inc., NJ. He may be reached at *joachim@roasting.biz* or by phone at 973.781.1111.

VISHWA ADLURI is vice president of Praxis International, Inc. He writes on a variety of subjects ranging from philosophy to coffee roasting technology and can be reached at *va@presocratics.org*.



FREE INFO #107



FREE INFO #142