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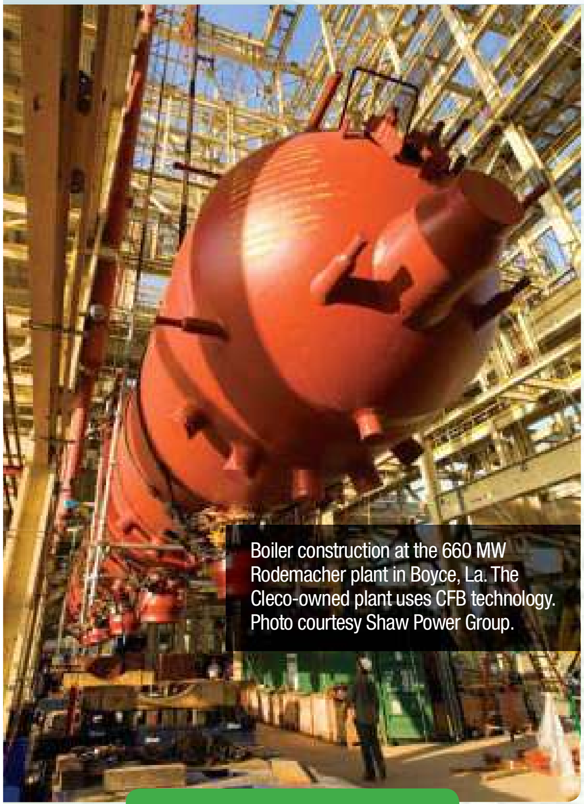

Boiler construction at the 660 MW Rodemacher plant in Boyce, La. The Cleco-owned plant uses CFB technology. Photo courtesy Shaw Power Group.

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The Triple Crown

Emulsified fuel technology can lower NO_x and greenhouse gases and increase fuel efficiency.

By Thomas Houlihan, Eco-Energy Solutions

Fossil fuel combustion, so fundamental to the economy of the nation, produces both NO_x and particulate matter (PM) emissions. Fortunately, there is a technology that reduces both. This technology can also increase fuel efficiency and decrease greenhouse gas emissions. The technology that can deliver this "triple-crown" of environmental and economic benefits is emulsified fuel technology (EFT).

Producing Emulsified Fuels

An emulsion is a mixture of two immiscible (not able to be blended) substances. For example, a fuel oil emulsion features water droplets—the dispersed phase—uniformly distributed throughout the fuel oil—the continuous phase. An emulsion takes on the characteristics of the continuous phase. Hence, fuel oil emulsions exhibit characteristics of fuel oil, not water.

Emulsions are inherently unstable. Over time they will separate into the stable states of the dispersed and continuous phase materials. To maintain the composition of an emulsion, surface active agents, or "surfactants," are incorporated into the production of an emulsion. In a fuel oil emulsion, these surfactant agents encase the droplets of water distributed throughout the continuous oil phase and prevent the water droplets from coming together and coalescing.

Producing an emulsion involves both chemical and mechanical operations. The formulation of an emulsion surfactant agent must take into account the need to preserve the stability of the emulsion in both storage and pumping operations as well as the need to render harmless the emission products arising from the combustion of the emulsified fuel.

The mechanical operation involved in producing emulsified fuel is that of a high-value (HV) shearing operation. The proper amounts of water, surfactant and fuel oil must be metered into the shearing volume to preserve the final emulsified fuel product's homogeneity. Computer-controlled fuel blending units are used to produce light and heavy fuel oil emulsions.

Emulsified Fuels Combustion

Traditional hydrocarbon fuel combustion requires the fuel first to be atomized. Once the atomized fuel droplets enter the combustion zone, they burn from the surface inward. This "char" burning of a fuel droplet is often not completed in the combustion zone and leads to PM generation. The generation of NO_x emissions proceeds from the exposure of fuel-borne nitrogen and nitrogen in the combustion air to the combustion zone's

Figure 1 REGULAR FUEL OIL COMBUSTION

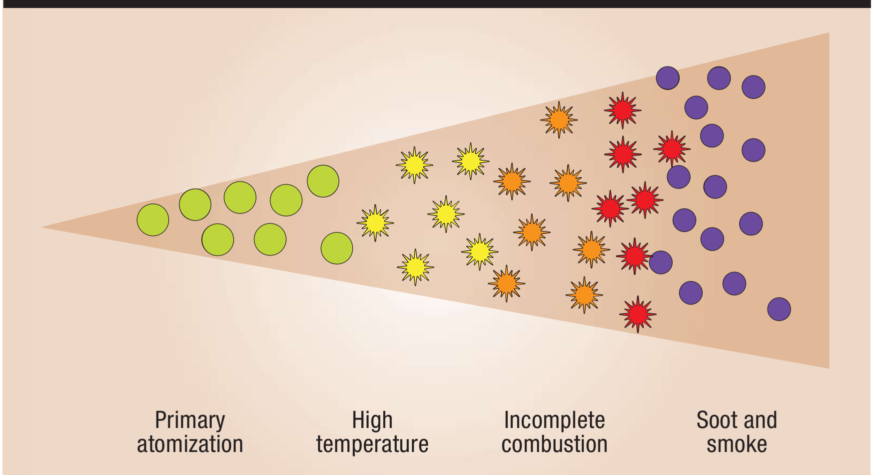

Figure 2 EMULSIFIED FUEL COMBUSTION

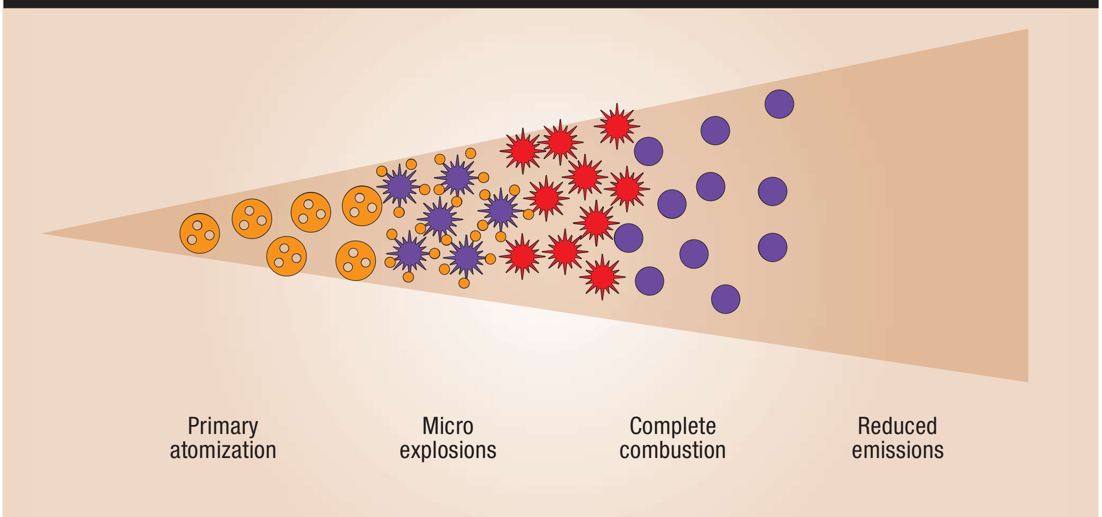

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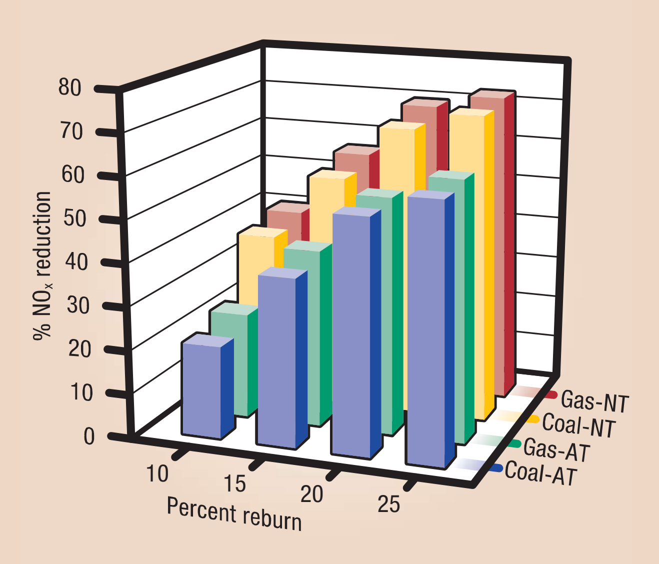
Figure 3 NO_x REDUCTIONS WITH FOE REBURN



high temperature refining atmosphere (See Figure 1.)

The combustion of emulsified fuels introduces water into the combustion zone, with two profound effects.

First, exposing the water droplets in an emulsified fuel to the high temperature of the combustion zone causes an immediate production of steam bubbles, a phenomenon know in the literature as a "micro-explosion."[1]

Each "micro-explosion" is accompanied by a significant increase in the surface area of the heretofore surfactant-encased water droplet and a subsequent shattering of the surrounding fuel oil medium into numerous auto-ignition centers of combustion. A more complete combustion is generated, resulting in less particulate matter (soot) production. (See Figure 2.)

Introducing water vapor into the combustion zone decreases the temperature of the combustion zone due to the water's high heat capacity. This decrease in combustion zone temperature leads to a less energetic oxidation of both fuel-borne and combustion air nitrogen contents and therefore to an overall decline in NO_X generation.[2]

More complete combustion means emulsified fuels can produce more power output per fuel input. Hence, the total amount of base (hydrocarbon) fuel required to produce a desired power output is less. If base (hydrocarbon) fuel usage is decreased, the oxides of carbon decrease. Emulsified fuels can thus contribute significantly to decreasing greenhouse gases (GHG) generation resulting from existent hydrocarbon fuel combustion.

In summary, introducing water into the combustion process by the use of emulsified fuels results in the generation of an enhanced "triple crown" of benefits: the reduction of emissions (NO_X and PM), an increase in fuel efficiency and the reduction of GHG. As such, emulsified fuel technology is one of the most effective and cost-beneficial technologies available to accommodate future requirements for hydrocarbon emission reductions, energy efficiency enhancement and GHG diminution.

Applications Reviewed at TVA, EER

Applications of emulsified fuel technology (EFT) have now been reviewed to validate the foregoing assertions at the Tennessee Valley Authority (TVA) and the Energy and Environmental Research (EER) Corp. (now part of General Electric).

TVA tested a diesel oil emulsion (DOE) in a GE Frame 7 combustion turbine at its Colbert Power Plant in Huntsville, Ala.[3] The test project generated nearly 302,000 kWh of uninterrupted electric power.

Tests were run on three different fuels, base diesel fuel (Series 100 tests) and two diesel oil emulsion (DOE) blends:

- 67.5 percent diesel, 30 percent water, (Series 200 tests)
- 62.5 percent diesel, 35 percent water (Series 300 tests).

According to the TVA test report, NO_X emissions were 53 percent lower on 30 percent DOE fuels (Series 200 test data) and 55.3 percent lower on 35 percent DOE fuels. Gross electrical power output increased more than 2 MW (4 percent) from base load with the use of DOE fuels.

EER tested the effectiveness of a fuel oil emulsion (FOE) as a reburn fuel in its pilot-scale Tower Furnace Facility in Irvine, Calif.[4] The TVA Allen Station Unit #1 in Memphis, Tenn. (a 330 MW power plant) served as the basis for projecting these pilot-scale test results to full-scale determinations of emission reductions.

In the EER test of #6 fuel oil emulsion in coal boiler reburn, the main fuels used were natural gas and coal. The reburn fuel was emulsified #6 fuel oil with a 30 percent (by volume) water content. Transport media for the reburn fuel included air (AT) and bottled nitrogen (NT). The nitrogen transport simulated the low O_2 content of a recirculated flue gas that is used as a transport medium for reburn fuel in power plants. NO_x reductions approaching 70 percent were projected (Figure 3) as reburn heat input with FOE fuel neared 20 percent of total heat input for the full-scale TVA power plant.

EFT Applied to Hydrocarbon Fuels

In addition to these applications, EFT can be readily applied to light distillate oils, like diesel oils, to operate in internal combustion engines that are either mobile or stationary. At the other end of the spectrum, EFT can be applied to residual oils to produce usable combustion products from such diverse stocks as vacuum tower bottom oils and pitch blends. Finally, EFT can be applied to biofuels to effectively counteract the rise in NO_x emissions arising from the combustion of such modern fuel blends.

In all instances, EFT presents a significant opportunity to use hydrocarbon fuels in all "flavors" to their maximum without fear of contributing exceptionally to harmful emission levels. As such, EFT is a true "enabling" technology that can deliver an immediate impact on global warming and community health.

EFT is a proven technology that summarily delivers on the promise of emissions reductions and increases operational efficiency. Lowering fuel heating temperatures and atomizing steam pressures when using emulsified fuels can contribute to an increase in overall plant operational efficiency, significantly lowering overall system maintenance costs. pe

Author: Dr. Thomas Houlihan was an engineering professor at the U.S. Naval Postgraduate School. He left academia to serve as Chief Engineer in the Navy Phased Maintenance Program and from 1994 to 1998, he was an ASME White House Fellow. Dr. Houlihan left this post to become senior engineer at Eco-Energy Solutions (EES) Inc.

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