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WHITE PAPER

Benefits of a Rich-Burn Engine Generator in a Standby Application

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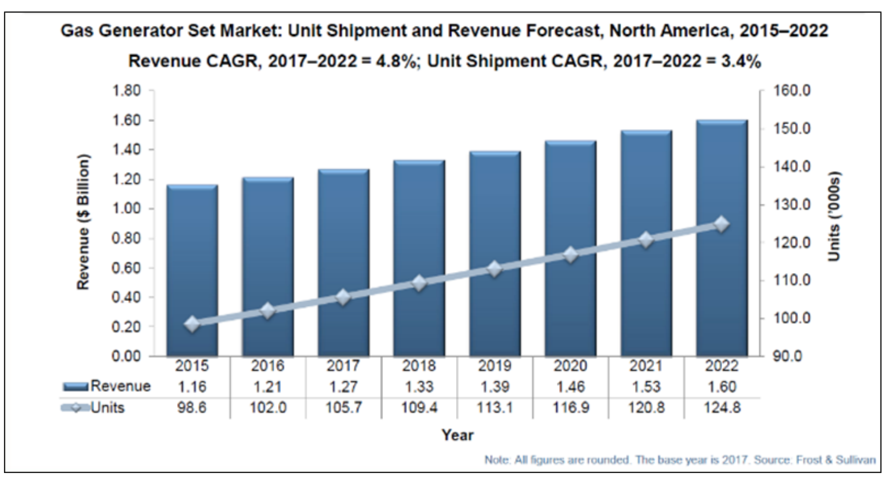
ABSTRACT

In natural-gas-fueled generators, a popular method for reducing and controlling emissions levels is to use catalytic reduction and air-to-fuel ratio (AFR) control. This can be applied to either a rich-burn or lean-burn engine. Choosing between the two comes down to what the customer's application needs are.

In standby applications, the benefits of rich-burn technologies outweigh those of a lean-burn approach. These benefits include improved emissions, better starting and load acceptance (including block loads) and superior tolerance of ambient operating conditions.

This paper will discuss all AFR approaches and explain why the rich-burn alternative is more appropriate for emergency standby power.



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INTRODUCTION

The shift towards natural gas generators has been accelerated by the low cost of natural gas as well as the overall demand for clean power generation. Severe weather and the power outages that result are likely to continue boosting natural gas generator demand in the industrial market. Natural gas is a virtually unlimited fuel source because it is utility-supplied, and its already clean-burning properties mean little to none of the expensive exhaust aftertreatment found on today's diesel-fueled gen-sets is required. As such, the gas generator set market segment is expected to grow up to $1.60B in North America by 2022.

Nonetheless, a popular method for reducing and controlling emission levels is to use catalyst reduction and air-to-fuel ratio control. Choosing between a "lean-burn" or "rich-burn" air-to-fuel ratio (AFR) comes down to what the customer's application needs are in terms of fuel flexibility, reliability, cost and standards compliance. Lean-burn gas engines sometimes operate at higher loads, but rich-burn engines can achieve lower emission levels and generally have better transient load capability.

NATURAL GAS GENERATORS AND THEIR COMBUSTION TYPES

Natural gas fueled generators can be categorized on the basis of the air-to-fuel ratio (AFR) with which they operate. This is generally represented by lambda (λ). Below are the three AFR types:

Stoichiometric: Stoichiometric AFR contains a precise ratio of air to fuel, and it produces a chemically complete combustion. The (λ) for stoichiometric AFR equals 1.00. In a stoichiometric AFR mixture, there is just enough air to burn each fuel molecule, with no excess.

Rich Burn: Rich-burn engines operate with the AFR at a higher concentration of fuel to air. It is a "fuel-rich" mixture. Rich-burn engines generally operate with (λ) equal to 0.995.

Lean Burn: Lean-burn engines operate with an AFR that has a lower concentration of fuel to air, making it a "fuel-lean" mixture. Lean-burn engines operate with (λ) anywhere between 1.5 and 2.2. This means that there can be twice as much air present than is theoretically needed to burn each molecule of fuel.

RICH-BURN VS. LEAN-BURN ENGINES FOR STANDBY APPLICATIONS

Approximately 80% of the global generator market is for emergency standby applications. In a life-safety application, the generator's ability to start and accept load can be a matter of life and death. Thus, in standby applications, the use of rich-burn engines has generally proven to offer significant benefits over lean-burn engines:

- Consistently provide better generator starting and load acceptance for standby use
- Excellent at picking up block loads due to the higher relative energy content of the AFR
- Have the ability to provide rated output power at higher altitudes and at hotter ambient temperatures because of their minimal turbocharging requirements
- Have better tolerance for variations in fuel quality and fuels with a lower methane number due to the inherent characteristics of the rich-burn combustion event

By contrast, lean-burn technology offers poor block-loading capabilities as well as poor performance at higher temperatures and altitudes. Most lean-burn engines also require selective catalytic reduction (SCR) exhaust aftertreatment, which is costly and requires high maintenance. Local emissions regulations may allow lean-burn engines to operate without an SCR, but they can still be required to have an oxidation catalyst to control carbon monoxide (CO).

Let's look at some of the benefits of rich-burn engines in standby applications in more detail.

Lowest Overall Emissions

When equipped with a three-way catalyst, rich-burn gen-sets provide the lowest emissions when compared to lean-burn units. A Generac factory-supplied three-way catalyst is a cost effective and easy-to-install product that can also act as a muffler. A rich-burn engine with this catalyst typically has oxides of nitrogen (NOx) emissions that are an order of magnitude below the engine-out values of the most advanced lean-burn engine technologies.

Robust Performance to Ambient Condition Changes

The smaller quantity of air and more stable basic combustion allow a rich-burn engine to perform more consistently through weather changes, i.e. humidity, temperature and barometer pressure. Rich-burn gen-sets also have a higher fuel antiknock tolerance than a lean-burn engine. This allows for greater fuel quality variation and operation on "hot" fuels like HD-5 propane.

Wide Load Operating Range

Rich-burn engines perform better in emergency standby applications because of their ability to accept a block load and operate at a wide load range. Lean-burn engines do not accept a block load well and perform poorly under varying loads. From a customer standpoint, this is typically quantified through application of the ISO 8528 standard, where the G2 class is typically the applied level from diesel generators. Rich-burn generators are capable of complying with the tight G2 performance standards, whereas lean-burn generators have to declare modifications to the stringent performance standards.

RICH-BURN ENGINES IN ENERGY MANAGEMENT APPLICATIONS (<2000 HOUR/ YEAR)

Along with emergency standby applications, Generac has optimized its rich-burn technology to be used in energy management applications such as demand response and peak shaving. The aforementioned benefits mean a low capital cost, allowing the end user to substantially decrease their peak demand charge compared to lean-burn engines.

Given the higher running hours in energy management applications, the typical industry thinking is that the fuel consumption advantages of the lean-burn solution will favor its use. However, the engineer must look at all capital and operating expenses in such an analysis to determine the optimal solution for the customer's application. There are many cases in which high-power-ratio, rich-burn engines actually deliver better fuel efficiency than their lean-burn counterparts.

CONCLUSION

The benefits of rich-burn technologies outweigh those of a lean-burn approach in standby applications. Improved emissions, better starting and load acceptance, as well as superior tolerance of ambient operating conditions are just a few of the benefits to a rich-burn engine. For more information about these concepts or the variety of Generac products available, contact Generac Power Systems at http://www.generac.com or toll free at 1-844-ASK-GNRC.

Author Background

Muhammad Armaghan is a Product Manager at Generac Power Systems. He is responsible for the Industrial Generator product line. Armaghan has experience working in industrial power generation markets and has supervised several multimillion-dollar projects throughout Unites States. These include power plants, healthcare facilities, data centers and municipal projects. Armaghan has also worked closely with consulting and specifying engineers, as well as general and electrical contractors and end users.