eTech
Heat Recovery Systems

Greengineering WhitePaper

What Really Counts in a Custom Economizer

Some boiler engineers will tell you that to get the full benefit from a boiler economizer, it must be custom-designed for the boiler. Others will tell you that an economizer is an economizer is an economizer, so boiler system-matching doesn't matter. Who is right?

In this white paper, we will lay out a case for the less common but often more effective practice of customizing an economizer for a boiler system. In the process, we will also highlight determinants of good economizer design.

The Fundamentals

To begin we offer an overview of economizer basics:

Purpose

- lower stack temperatures
- preheat boiler feedwater
- increase boiler efficiency by at least 3%–5%
- reduce fuel consumption
- Save you money

Applications

- firetube boilers (typically 100–2500 hp)
- watertube package boilers (up to 400,000 pph)
- fired hot water heaters
- thermal oxidizers
- engine and turbine exhaust systems

Formats

- rectangular
- cylindrical
- down-the-stack
- field-erected

Within each economizer format, sizes will vary to suit a particular function or application.

Design Considerations

Since the economizer is part of the boiler train, it follows that the more seamlessly it integrates with the boiler in design and materials, the more effectively it will perform within the rigorous boiler environment.

Many prerequisites go into making an economizer that achieves this level of integration. The most basic criterion is that the economizer should operate under the same ASME code section as does the boiler: ASME Section I. Although some material considerations could mandate Section VIII codes, this would be a rare exception.

The economizer should use the same tubing as the boiler: In most cases this would be SA178 Grade A. Given that the economizer operates under conditions similar to those experienced by the boiler, it stands to reason that it should utilize this same high-pressure boiler tubing. Also worth noting is that this material offers significant savings

over stainless, which is not needed in situations where boiler feedwater is deaerated.

Since the heart of an economizer is its heat transfer surface—i.e., the finning—the most desirable method of fin-to-tube attachment would be high-frequency resistance welding. This is the same process used in the manufacture of SA178 tubing, and assures the strongest bond available. This finning is specified for Heat Recovery Steam Generators (HRSG) almost exclusively. For dirtier fuels solid fins provide a lower-maintenance design; for clean-burning fuels, serrated fins offer cost savings.

Some manufacturers provide fused or brazed fin-to-tube attachment, which can be manufactured less expensively. However these types of attachments often introduce dissimilar metals with varying rates of thermal expansion. This eventually can cause the finning to peel off "slinky style."

In a properly designed economizer, all pressure parts are exposed to flue gases. This is sometimes called "hot structure" design. Keeping the pressure parts hot helps to protect them from acidic corrosion. For this reason, it is most desirable to situate them in the flue gas stream. However some manufacturers' economizers are designed in such a way as to isolate these pressure parts, particularly headers, which presents a less than optimal situation.

Depending upon fuel type, the tube arrangement of an economizer may be either square or staggered. For relatively dirty fuels such as coal, wood and #6 fuel oil, an in-line (square) tube pitch is preferred as it is easier to clean. With clean-burning fuels, a staggered pitch offers enhanced heat transfer, making it preferable. Because there is little or no fouling, cleaning of the heating surface need not be a consideration.

Some economizer designers use compression fittings to connect the tubes and the feedwater piping. Their justification is that this method allows for convenient replacement of tubes. In reality, though, the driver behind this design approach is cost: A compression connection is cheaper than a welded one. However, because of its inferiority to a welded joint, a pressure fitting connection is prohibited under Section I. Manufacturers who use compression fittings offer Section I-compliant welded joints only at an added cost.

Just as with the boiler, a weld provides the only proper connection for an economizer. Contrary to what some manufacturers imply — or outright claim — a welded joint does not in the least diminish the ability to replace tubes. What's more replacement tubing suitable for welding is easy to find locally. On the other hand, replacement tubing engineered for a compression fitting must be sourced from the manufacturer. This leaves the customer at the mercy of manufacturer stocking and delivery practices.

Some manufacturer's specifications require an internal gas bypass in their economizers. No heat transfer occurs when gas bypasses the heating surface, therefore the only explanation for this practice can be that it's used as a means to control gas or liquid temperatures. However an internal bypass makes no useful contribution to economizer efficiency and only adds cost to the unit. A properly designed economizer will be engineered to achieve temperature control without the addition of an element that contributes nothing but needless complexity and cost.

In addition to the aforementioned features and benefits, a hot structure design also introduces a number of structural advantages to an economizer.

In a hot structure economizer, the inner casing should be a minimum of 10 gauge and should be completely seal welded to prevent the escape of flue

gases into the boiler room. In a traditional non-condensing economizer, the inner casing would be carbon steel.

This inner casing should then be insulated, typically with mineral wool at a thickness of two to four inches, depending on the temperature of the flue gas. Covering the insulation would be an outer casing. This casing might be fabricated from one of a variety of materials. A thin-gauge carbon steel lagging usually is appropriate, though for the sake of appearance, some opt for a more attractive — and also more expensive — flat outer casing. In addition, many customers request removable end panels to allow easy access to headers and return bends.

As mentioned previously, economizer designs are usually rectangular or cylindrical, each shape presenting particular advantages. Cylindrical economizers offer a relatively inexpensive economizer option for smaller boilers ranging from 100 to 1500 BHP. As most stacks are round, they can be more easily fitted with a cylindrical economizer, thus preventing the need for costly transitions.

Additionally, coiled economizer designs require far fewer welds than other types. The fewer the welds, the fewer the number of possible failure points in the economizer.

Rectangular economizers, although adaptable for smaller boiler sizes, are less economically viable in these applications than circular units. On the other hand, for boilers of 50,000 PPH and larger, the rectangular design becomes the preferred and more cost-effective choice, given this format's ability to accommodate a greater heat transfer demand.

The final factor in the decision in choosing among economizer manfacturers is the warranty that covers the unit. Buying an economizer is usually a significant capital investment and the buyer should receive, at minimum, certain warranty considerations:

1. Thermal performance at full fire should be guaranteed.
2. The warranty for materials and workmanship should cover a period of at least 12 months after startup or 18 months after shipment. This warranty should cover materials and labor up to the amount of the purchase order.
3. All ASME paperwork, as well as manuals and Material Test Reports (MTR) should be provided within a few days of finished fabrication.
4. Startup assistance, at appropriate fees, should be available from the manufacturer or its representative, if requested by the customer.

The decision whether to go with a fully custom or semi-custom economizer manufacturer naturally will be influenced by timeline, budget, application, projected ROI and expected performance. To get the complete value picture, though, it is important to consider both long-term and short-term results.

In the short term, the lesser expense of a semi-custom unit may seem like a sensible choice, but as this paper has shown, there is a case to be made that seamless boiler integration can and often does prove to be the better option.