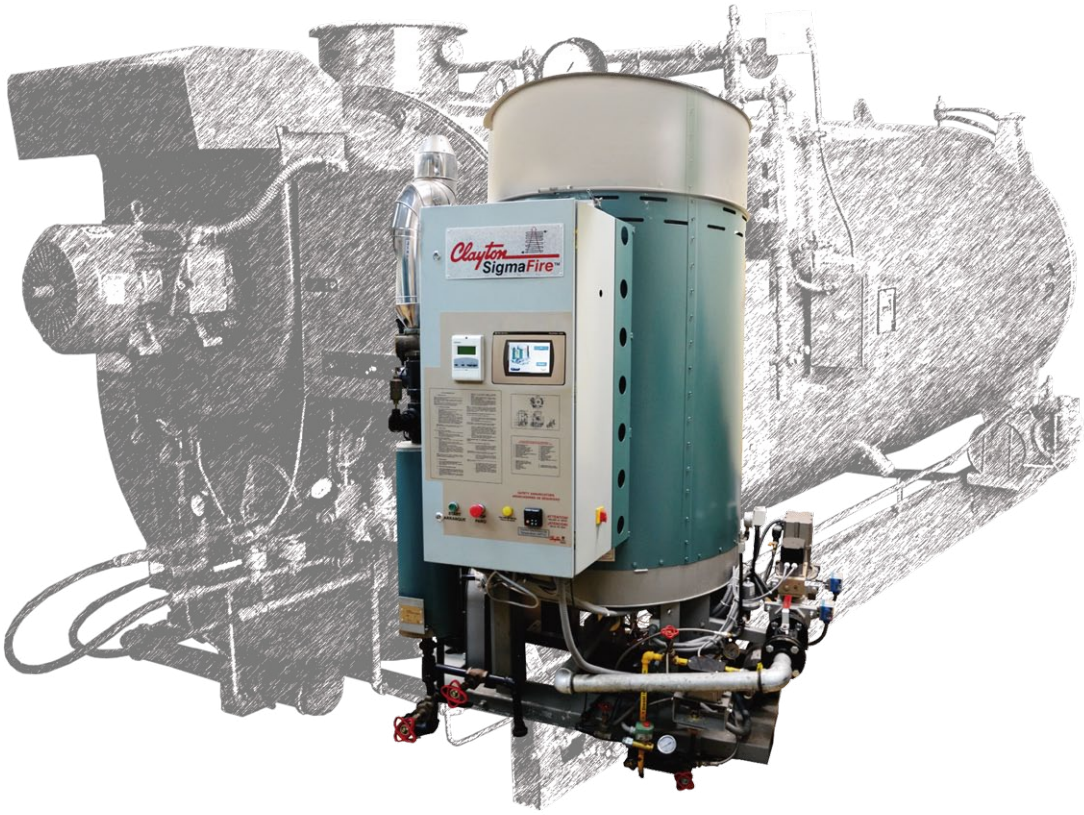
Clayton®
Integral Steam Solution

Comparative Study

Efficiency Steam - Fuel



San Diego State University, a majar university ranked among the top six percent of al! American Universities, performed a comparative efficiency analysis between steam generators and firetube boilers. In particular, attention was paid to checking the validity of the assumptions, and the integrity of estimations made by the manufacturers in their efficiency calculations. For this study, San diego State University compared a 300 horsepower Clayton Steam Generator to a 300 horsepower Cleaver Brooks firetube boiler.

The majar losses closely examined in this study were: Radiation and Convection (R&C) Losses, Blowdown Losses, Stack Losses and Steam Quality Losses. The results of this study conclude that despite published efficiency numbers, the Clayton Steam Generator averages 5.8% higher efficiency across the entire operating range than the Cleaver Brooks firetube boiler.

Comparative Study

SAN DIEGO STATE UNIVERSITY

The table below summarizes the analysis performed, including corrections of unrealistic operating assumptions made by the firetube boiler manufacturer.

LOAD	25%		50%		75%		100%		PROM
TIPE	FT	SG	FT	SG	FT	SG	FT	SG	
IDEAL EFFICIENCY	100	100	100	100	100	100	100	100	
R&C Loss	<6.0>	<2.6>	<3.0>	<1.3>	<2.0>	<0.88>	<1.5>	<0.66>	
Stack Loss	<16.6>	<14.3>	<16.5>	<14.3>	<16.6>	<14.3>	<16.6>	<14.3>	
BLOWDOWN LOSS	<1.5>	<0.75>	<1.5>	<0.75>	<1.5>	<0.75>	<1.5>	<0.75>	
STEAM QUALITY LOSS	<1.5>	<0.5>	<1.5>	<0.5>	<1.5>	<0.5>	<1.5>	<0.5>	
CORRECTED THERMAL EF.	74.4	81.85	77.4	83.15	78.40	83.57	78.90	83.79	5.8

Radiation and Convection (R&C) losses must be analyzed in a realistic environment. The firetube boiler manufacturer assumes that boiler room air does not circulate which is impossible considering combustion air must be supplied to the boiler blower. Therefore, R&C losses are recalculated based on a realistic operating environment and the surface area exposed. Losses are inversely proportionalto firing rateoR&Closs is 0.84% higherfrom a firetubeboilerat 100% increasing to 3.4% at 25% firing rate.

Stack losses must conform to thermal dynamic laws. A firetube boiler is a parallel heat exchanger and therefore stack temperature must be higher than the temperature of steam produced. A Clayton Steam Generator is a counterflow heat exchanger and stack temperature can be below the temperature of the steam produced. This study calculated the efficiency of the firetube boiler at 2.3% less than the steam generator based on the difference in stack temperature.

Blowdown loss occur in all boilers. The design of a steam generator concentrates high levels of dissolved solids in the steam separator. Therefore the quantity of the blowdown water at full saturated steam temperature that is lost is approximately one half that of a firetube boiler. The blow down losses of a firetube boiler are 1.5% and the loss in a steam generator is 0.75%. Which gives the steam generator O.75% high~r fuel to steam efficiency.

Steam quality is better from a steam generator than a firetube boiler. The technical specification of the firetube indicates steam quality of 98.5% versus 99.5% from a steam generator. The carryover or water portion of the flow is not useable and must be eliminated from the steam system, representing an additional loss. The quality difference results in 1% less usable steam from a firetube boiler and, therefore, 1% less fuel to steam efficiency.

The conclusion reached by San Diego State University is that by applying realistic assumptions and measuring true fuel to steam' efficiency of the whole boiler system that the efficiency numbers published by Cleaver Brooks are overstated.

The Clayton Steam Generator is 4.9% more efficient at 100% output, 5.2% more efficient at 75% output, 5.8% more efficient at 50% output, and 7.5% more efficient at 25% output.

The efficiency advantage of the steam generator increases above these amounts if steam demand fluctuates. Additional fuel is saved during start-up of the steam generator which reaches full output within five minutes of a cold start.

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