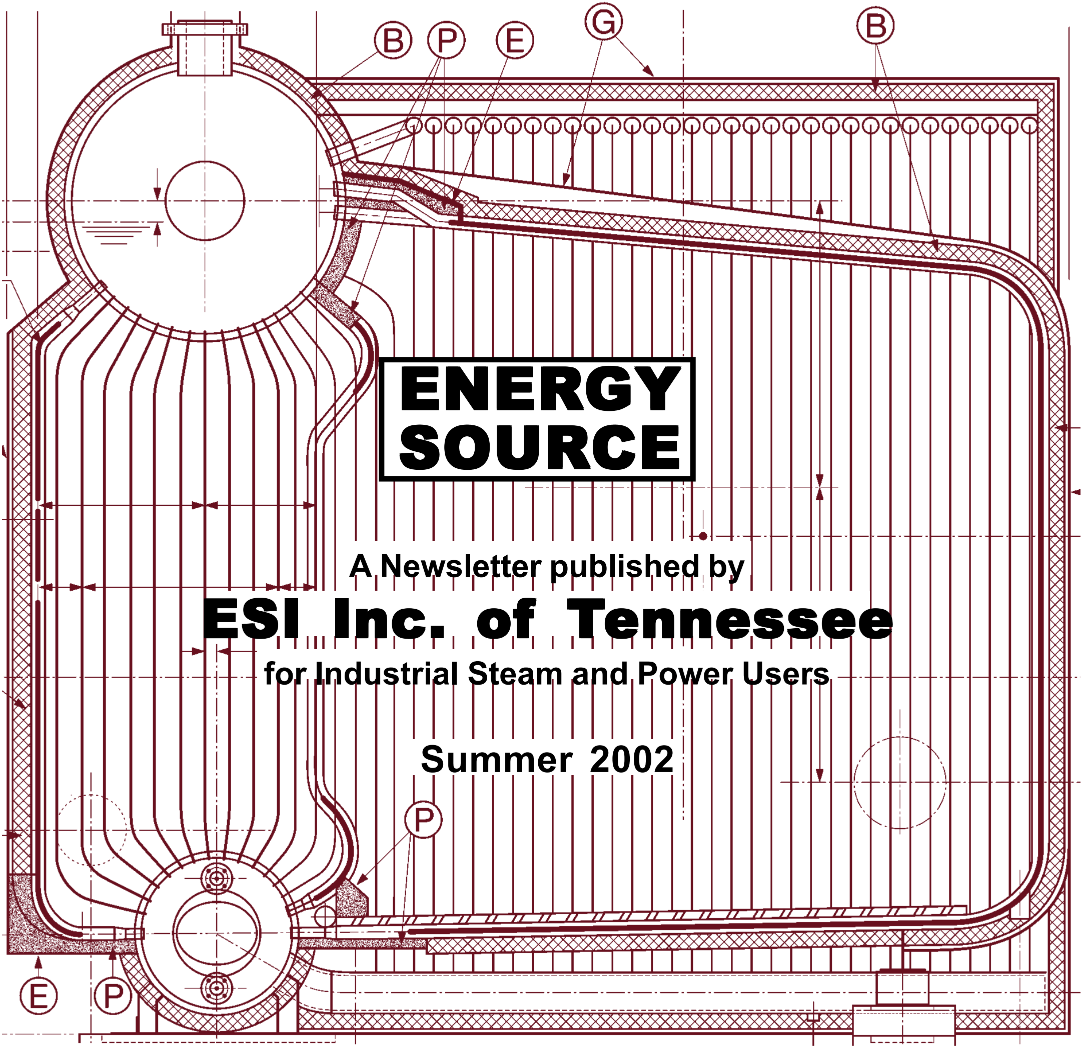

ENERGY SOURCE

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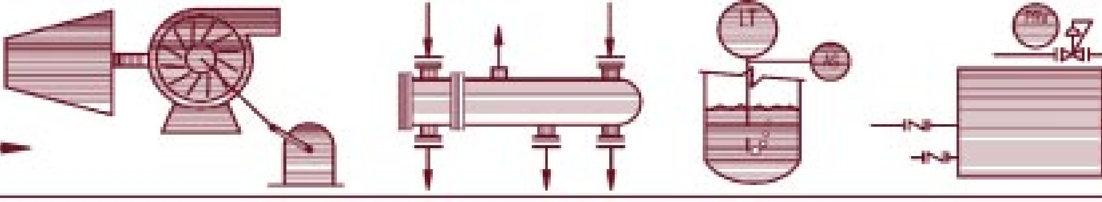
for Industrial Steam and Power Users

Summer 2002



Cogeneration – Combustion Turbine Selection

By: Ronald T. Helton, P.E., Mechanical Engineering – Operations Manager, ESI

The primary component of a combustion turbine based cogeneration system is the combustion turbine (CT). The recent heavy activity in the market has resulted in numerous small turbine products, sometimes called microturbines, with capacities starting at 400 KW (535 HP) and going up from there. Although many of the concepts addressed in this article apply to all CT sizes, we will primarily discuss combustion turbines in the smaller (less than 50 MW) size range.

To most people, the term combustion turbine probably makes them think of a gas turbine. This is likely due to the fact that natural gas has been utilized as the fuel source for the majority of recent projects and most CT manufacturers' performance literature (predicted output, heat rate, exhaust temperature, etc.) is based on natural gas. The fact is that combustion turbines can be configured to fire a variety of gaseous and liquid fuels. As with almost any combustion technology, the key to a successful project relies on tailoring the machine to the specific fuel and to have a reliable, predictable, and consistent supply of fuel available. On a similar note, although CT's are mostly used as generator drives for electrical power production, they can also be used as mechanical drives for a variety of rotating equipment.

Cycle Configurations

There are several basic cycle configurations that use CT's as the primary component. They are listed and discussed below in order of increasing complexity: Power Production Only, Simple CT Cogeneration Cycle, and Combined Cycle.

Power Production Only – The CT drives a generator for power production (or mechanical drive) only. Heat from the turbine exhaust is not recovered. Typical use is for peaking units in electrical power production.

Simple CT Cogeneration Cycle – Cogeneration is the simultaneous generation of electrical power and thermal energy. The exhaust heat from the CT is partially recovered by a Heat Recovery Steam Generator (HRSG) or other means (such as a process heater or some direct means of heat recovery). Further variations for this cycle fall around the configuration of the HRSG. In its most basic form, the HRSG is single pressure and unfired (no additional heat was added to the exhaust stream). Variations include multi-pressures, supplementary fired, and fully fired HRSG's. This cycle typically provides the highest rate of return for users who are able to implement a fairly simple system that has enough flexibility for their operational needs. This is due to the high overall system efficiency as compared to utility power plants.

Combined Cycle – Combined cycle is the generation of electrical power using both a CT and steam turbine generator in the same system. The CT/HRSG is coupled with a steam turbine generator to produce electrical power and steam. Variations for this cycle include the use of fired or

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Deanna White
Managing Editor

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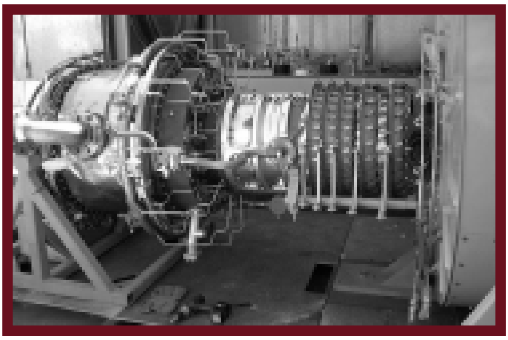
unfired HRSG's, single or multiple pressure level HRSG's, and non-condensing or condensing steam turbines. Further variations for the steam turbines include extractions and/or admissions. While the combined cycle can get very complicated, it does provide a significant amount of flexibility in meeting both steam and power loads. This flexibility does come at a price. While it is theoretically possible to design and build a very small combined cycle plant, economics usually only justify these in the much larger sizes (40 MW and up, with most being 100 MW or more) and usually utilize multiple CT units.



ESI recently installed this Solar Taurus 7.5 MW Combustion Turbine.

New Cogeneration Facility recently completed by ESI.

As you can see from the long list of cycle options available, choosing a configuration can be a real challenge. All of the options above center around equipment other than the combustion turbine. With the CT being the heart of the system, let's look at evaluating performance and enhancing the power output of these machines. These points are applicable no matter which basic cycle configuration is chosen.

Evaluating CT Performance

While there has been a push to standardize CT ratings, the market is still not consistent. This means that the user must be diligent in assuring that he is comparing apples to apples when looking at different manufacturers' offerings or even offerings within a manufacturer's line. The trend is to standardize at ISO Rating, which allows for 15°C (59°F) sea level ISO conditions on natural gas fuel for electric power generation and mechanical drives. They do not include any duct losses for inlet or outlet to the CT. Some items to watch out for are as follows:

- Non-ISO inlet or outlet losses. Typical simple cycle plants have 4" (H_2O) inlet filter loss and 4" outlet loss for the CT/HRSG. This can result in a 2% reduction compared to the ISO power rating. Fired HRSG's can see 10" exhaust loss, which can equate to even a larger reduction in CT output compared to the ISO rating.
- Nominal ISO ratings for electrical power generation are quoted as gross power output measured across the electric generator terminals. They reflect generator efficiency and any reduction gearing losses. Gearbox losses vary but are usually in the 1% to 2% range.
- Generator losses in the size range we are discussing are typically in the 2% to 4% range.
- Mechanical drive ratings are quoted at the turbine output shaft coupling.

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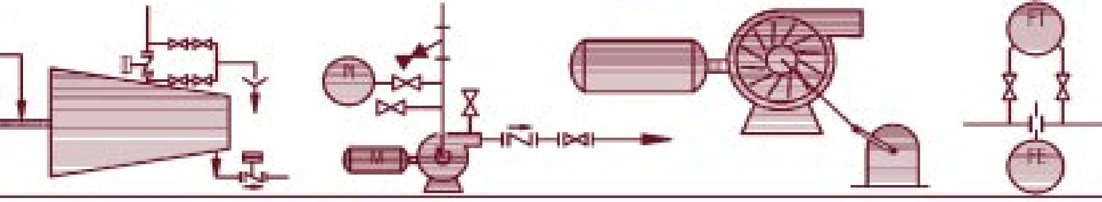


Are Your Operators Properly Trained?

By: Jeffrey H. White, P.E., Vice President of Sales, ESI

Over the years, ESI has written several newsletter articles and had several articles published that all point to the importance of properly trained operators. Whether your concern is for personnel safety and/or the operational reliability and availability of the steam generation equipment, properly trained operators are critical. Regard for personnel safety is an item that is foremost in the design, construction, operation, and maintenance of industrial manufacturing facilities; however, sometimes serious and fatal injuries are caused by catastrophic equipment failure that stems from years of seemingly innocent neglect or poor operation and maintenance. On the other hand, the operational reliability and availability of steam generation equipment are often critical to facility profitability.

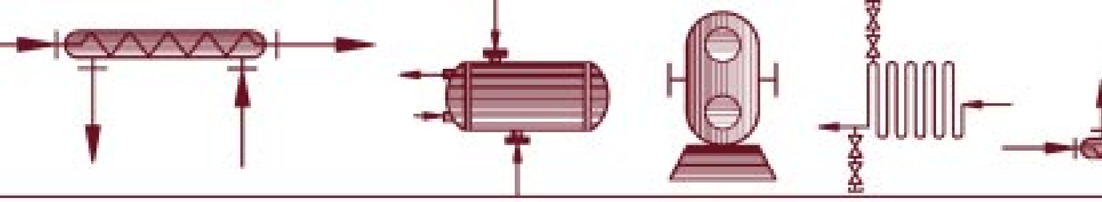
ESI spends extensive time and effort on operator training for all of our design/build projects. Our approach involves analyzing the experience and knowledge of the current operating personnel and evaluating how the plant will be operated on a day-to-day basis. We then structure a training program specifically designed for that steam and power facility.

ESI develops an operations manual specifically designed for the facility that emphasizes issues such as safety, emergency situation decision-making, normal operation, and a list of routine maintenance items. It includes an explanation of how the steam and power equipment functions in relation to the rest of the plant as well as the basic theories behind how the equipment operates. We feel that this limited theory is required in order for the operator to understand the effects of his decisions and actions.

Once the operators have reviewed the manual, ESI will then make a formal presentation, which consists of classroom sessions intermingled with visits to the boiler room to look at the items covered in the classroom session. During this training, ESI personnel will literally take the operator by the hand and teach him the function, operating requirements, and potential dangers of each piece of equipment. Upon completion of the hands-on training, a written open book exam is usually given to the operators. Then, if necessary, additional training can be provided in the appropriate areas.

Many industrial and commercial facilities tend to minimize or ignore the importance of steam and power plant operator training. The best facility will suffer operating difficulties if the operating staff is not properly trained. ESI has performed training for all of the installations we have designed and built, as well as for facilities which were installed by others. The following page highlights a few Boiler Safety Operation and Maintenance Practices. Do your operators know why these practices are critical? A properly trained operator knows why his actions are critical.

If you are unsure about the current competency level of your operators and their ability to handle an emergency, a preliminary operator's exam could be administered. This information could then be used to determine if training is needed and if so, could assist in designing a training program suitable for your operators. If you are interested in receiving a copy of ESI's Operator Test along with the answer key to administer to your operators, please call Jeff White at 770-427-6200. Our Operator Test is also available on-line at www.esitenn.com.



BOILER SAFETY

Operation and Maintenance Practices

- Frequently observe the burner flame, especially when firing oil to identity plugged sprayer tips and other combustion problems. This approach provides an early warning.
- Investigate and identify the cause of any trip before attempting to relight.
- Before lighting a boiler, always purge the furnace thoroughly.
- Perform routine maintenance, calibration, and testing of the burner management system and combustion controls, especially safety devices and transmitters.
- Verify that the water treatment system is operating properly, producing boiler feedwater of sufficiently high quality for the operating temperatures and pressure involved. Although zero hardness is always an absolute criteria, other water quality standards based on operating pressures and temperatures as recommended by ABMA should be followed. Never use untreated water in a boiler.
- Blow down all the dead legs of the low water trips, water column, etc., on a regular basis to prevent sludge buildup in these areas, which leads to device malfunction. Never, under any circumstance, disable a low-water trip.
- Verify that water leaving the deaerator is free of oxygen, that the deaerator is operated at the proper pressure, and that the storage tank water is at saturation temperature. A continuous vent from the deaerator is necessary to allow the discharge of noncondensable gases.
- Continuously monitor the quality of process to enable the diversion of condensate in the event of a catastrophic process equipment failure.
- Adjust continuous blowdown to maintain conductivity of the boiler water within required operating limits and operate the mud drum blowdown on a regular basis. Never blow down a furnace wall header while the boiler is operating.

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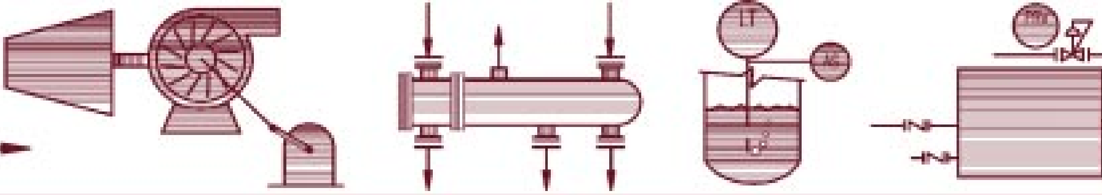

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- Power for electrically driven auxiliary equipment (lube oil pumps, coolers, ventilation fans, etc.) must be considered when calculating net power output. The difference between the gross power generated and the net power output is defined as the parasitic power use that is consumed by the cogeneration system itself.
- ISO output power is quoted based on natural gas as fuel. Some manufacturers will quote equal performance on liquid fuels while others can be as much as 2% to 3% worse on liquid fuels.
- The specific site altitude and temperature range is also very important in optimizing a selection. These two factors introduce substantial variability in output power rates as the CT is merely an air-breathing engine whose output is proportional to the mass air flow entering the compressor; i.e., power output is diminished during summer temperatures and at elevated locations. While most CT's provide optimum output at ISO conditions, it is possible to shift the optimization away from ISO to better meet the specific needs of the customer. Evaluations could show that one manufacturer's offering is inherently more suited to the specific application than another's offer. Beyond this there are other means to enhance the power output at off-design conditions. These include evaporative cooling, mechanical chillers, absorption chillers and thermal energy storage systems. The simplest of the above to incorporate is evaporative cooling. While it is true that the most benefit from evaporative cooling is obtained in arid climates, the contribution from this technology can benefit CT power enhancement even in more humid areas. An example is the enhancement of power output at a Georgia utility by more than 1% with the simple addition of this technology. Keep in mind that, regardless of location, evaporative cooling cannot cool inlet air below the ambient wet bulb temperature.
- A common practice when evaluating a combustion turbine is to focus on the guaranteed heat rate and efficiency. The heat rate and efficiency are absolutely critical for a CT used only for peak power production. However, heat rate and efficiency are often not key factors in the selection of CT for a cogeneration application. In fact, ESI has worked on projects whereby a less efficient CT was more desirable because of the overall plant heat balance between electrical power and thermal energy needs. A less efficient CT translates into a higher turbine exhaust gas temperature and/or higher mass flow rate. This results in a higher steam production from the HRSG for the same electrical production; however, the overall system efficiency remains the same. There are cases when a less efficient CT actually results in improved project economics because of the particular system heat balance.

The above variations in output of 1%, 2% or 3% may not sound like a lot, but they can make the difference in meeting a plant's needs during a critical time period or even in the overall feasibility of a cogeneration project. This reinforces the fact that a successful cogeneration project must have the full participation of the owner(s), engineer, equipment supplier(s) and utility. Engineering decisions must be made with as much information as possible, including a good understanding of all restraints, redundancy requirements, output needs, economics and operational issues.

If you have any questions concerning this article or have a possible cogeneration application, please call the *SPECIAL FORCES*™ of the Steam and Power Industry today at 770-427-6200 or e-mail us at info@esitenn.com. Look for our next issue, *ENERGY SOURCE* Fall 2002, where we will continue this cogeneration series.