

Pre-commissioning cleaning of 4 Heat Recovery Steam Generators (HRSGs) in Egypt

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Combined Cycle Power Plant

A Combined Cycle Power Plant has two turbines. The first turbine is a gas turbine that is driven by burning, for example, natural gas. The second turbine is a steam turbine that is driven by the steam that is heated by the residual heat from the exhaust gases of the gas turbine (see the figure). Both turbines drive a generator where the electricity is produced.

The electrical yield of this system is considerably higher (approx. 60 %) than when only one turbine is driven.



Photograph 2

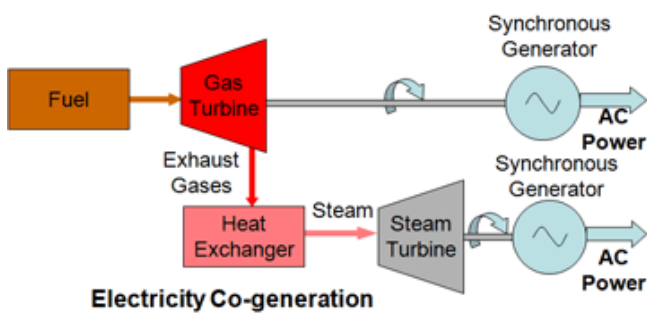


Figure Principle combined cycle ¹

The section where the steam is produced to drive the steam turbine is referred to as a Heat Recovery Steam Generator (HRSG); see photographs 1 and 2. An HRSG often has three sections: LP (Low Pressure), IP (Intermediate Pressure) and HP (High Pressure). Every section includes a steam drum and an evaporator section. Water is converted to steam in the evaporators. This steam will still run through superheater sections where the temperature of the steam will be increased before it is led to the steam turbine.



Photograph 1

Project in Egypt

Two Combined Cycle Power Plants are being built in Egypt; one in Sidi Krir (approx. 30 km to the west of Alexandria) and one in Mahmoudiya (El Atf) (in the north western Nile Delta). PGESCO will be building both plants that are virtually identical. PGESCO is a joint venture of the Egyptian Ministry of Electricity and Energy, Bechtel Power Corporation (USA) and a bank (Commercial International Bank of Egypt). Each plant has two 250 MW (megawatt) gas turbines. The exhaust gases of each turbine will be led to its own HRSG. A 250 MW steam turbine will be driven with the steam from the two HRSGs. The net capacity is, therefore, 750 MW.

The HRSGs for both plants have been designed, delivered and built by the Dutch company NEM. Often chemical cleaning takes place before an HRSG is commissioned. This is referred to as pre-commissioning cleaning. The contaminants to be removed consist of loose contaminants (including sand), grease, oil, surface rust and welding scales. After the pre-commissioning cleaning, the water side of the HRSG will be metallic blank and will have been completely passivated. When the HRSG is commissioned, a magnetite layer will form on the water side that protects the material against corrosion.

Vecom Cleaning Manual

NEM has placed an order with Vecom to carry out the chemical cleaning of the four HRSGs. Vecom has produced two Cleaning Manuals (one for each site) in consultation with NEM for this purpose. A Cleaning Manual is a type of script in which the full chemical cleaning is described. It is exactly determined which sections of the HRSG must be cleaned and based on which flow charts this should be performed by using detailed P&IDs (Piping and Instrumentation Diagrams). This is referred to as Engineering. In addition, the full chemical procedure is also

described in this manual. Vecom and NEM had to pay two visits to the Egyptian subcontractors to produce the Cleaning Manuals. In addition, Vecom and NEM have held several meetings to ensure that everything was harmonised properly with each other.

Chemical procedure

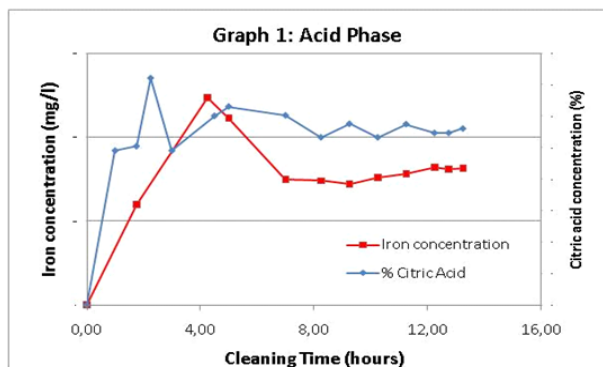
Nowadays, many HRSGs are cleaned using hydrofluoric acid (HF), in particular, in Europe. However, HF is a toxic acid that can cause serious burns. The four HRSGs in Egypt have, for this reason, been cleaned by applying the citric acid method. Chemical cleaning with inhibited citric acid is a good alternative. However, a high temperature (80 – 90 °C) is required to ensure that the iron oxides are correctly dissolved. This can partially be compensated by adding ammonium bifluoride. This ensures that you can clean using a lower temperature.

Citric acid method

Chemical cleaning using citric acid includes the following cleaning steps:

- Pre-flushing at high speed to remove all loose contaminants (including sand).
- Degreasing phase: oil and grease contaminants are dissolved by using a detergent.
- Descaling phase: the inhibitor and the citric acid are mixed with the degreasing liquid (using a specific ratio). Next, ammonium bifluoride is added and the pH is slightly increased by adding ammonia to ensure the solution is less aggressive. A number of parameters are analysed continuously during descaling to determine the progress of the cleaning. The iron level and the citric acid concentration provide a picture of the cleaning progress. If this is stable, the descaling phase will be finished (see graph 1).
- Flushing phase at high speed to remove acid residue.
- Removal of flash rust: the flash rust that forms during draining and flushing is removed using a low concentrated citric acid solution.
- Passivation: the citric acid solution is neutralised using ammonia until a high pH is obtained. The passivation is started by adding an oxidator. Passivation involves oxidising the reactive iron surface to a (temporarily stable) uniform $\gamma\text{-Fe}_2\text{O}_3$ layer.

All wastewater is stored in a temporary storage facility after which it is taken away to a local processor using tanker lorries. The method as it has been carried out in Egypt by Vecom generates considerably less wastewater than conventional cleaning methods.



After cleaning

After cleaning, the HRSGs were inspected by PGESCO, NEM, Vecom and the end user (the customer). All four HRSGs were immediately approved without there being any issues. All steam drums have a metallic blank surface. The greasy contaminants and iron oxides dissolved completely. See photographs 3 and 4 to view the cleaning result.



Photograph 3



Photograph 4

Steam blows are performed after chemical cleaning. The sections that have not been chemically cleaned are also stripped of loose contaminants (sand) and oxides during this process. These contaminants could otherwise damage the turbine rotor blades.

Both HRSGs in Mahmoudiya have already completed the steam blow process (see photograph 2 on page 1 at the top).

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