MOTIVA ENTERPRISES LLC
DELAWARE CITY REFINERY
REPOWERING PROJECT
OVERVIEW AND PROJECT STATUS

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INTRODUCTION

The Motiva Enterprises Delaware City Refinery Repowering Project is an integrated gasification combined cycle (IGCC) plant which will generate electric power and steam using petroleum coke produced at the adjacent refinery. Two Texaco Power and Gasification (TPG) dual oxygen blown gasifiers and an acid gas removal process will produce clean syngas for two combustion turbines and heat recovery steam generators (HRSG), which in turn supply supplemental steam to existing steam turbines and provide high pressure steam to the refinery. Included in these new facilities is a new air separation unit (ASU) which supplies oxygen and other industrial gases required for these facilities and for debottlenecking the refinery’s existing sulfur plants.

The plant is designed to use all the fluid petroleum coke generated at Motiva’s Delaware City Plant and produce 1250# steam, 175 # steam for export to the refinery and the use/sale of 120 MW of electrical power. Of utmost importance to Motiva is that these new facilities provide the same high degree of reliability for steam and electric power as provided in the past with the existing power plant facilities. In addition, the ASU will produce liquid products for merchant sale. Environmentally, these new facilities will help satisfy tighter NO\textsubscript{x} and SO\textsubscript{2} emission limitations expected for the Delaware City Plant.

There were several key drivers for this project. One of these was to utilize all of the refinery’s production of petroleum coke in order to eliminate the costly disposal of this high BTU waste fuel. Another was meeting the environmental regulations utilizing the high sulfur petroleum coke and providing a highly reliable new source for high pressure steam. This allows the refinery to rely less heavily on less efficient existing boilers. A third driver was to provide additional flexibility and future diversity in the refinery, which would enable the refinery to enhance its economic profile.

CONSTRUCTION AND INITIAL STARTUP

The construction of the facilities started in April 1998 and was completed in stages with the Air Separation Unit commissioned in November 1999 and restarted for commercial operation in May 2000. The Power Block was commissioned in March 2000 on low sulfur diesel with introduction of syngas to Unit 1 in September 2000. The Grinding/Mill area was commissioned and started up in March 2000 and the Gasification Block commissioned in April/May 2000 and started up in July 2000.

The Air Separation Unit provided by Praxair has been in commercial operation producing nitrogen, oxygen and argon. The performance test is scheduled for early October 2000.

The Combustion Turbines and HRSG’s have been successfully operated on LSDF. To date limited run time on syngas has been performed.
Gasifier Trains 1 and 2 have been operated for runs of 40 minutes to 5 days. The operation’s team is working through startup issues to increase run times. The major problem encountered in the gasification trains is lockhopper system pluggage.

**PROCESS DESCRIPTION**

The TPG oxygen-blown entrained flow gasification technology is used to produce syngas from petroleum coke. The plant modified a coke storage yard and four existing elevated coke storage silos to handle coke and sand and limestone fluxants. These tie in to new dual coke conveying, grinding and slurry preparation facilities and dual coke gasification facilities. Downstream is a single acid gas removal unit followed by dual advanced combustion turbine generators, each with a heat recovery steam generator; and a single air separation unit. The existing Delaware City Plant Power Plant steam turbine-generators, Boilers No. 1, 3 & 4, and water treatment plant are also utilized by this project. Figure 1 is a simplified Block Flow Diagram for the coke gasification plant.

Syngas produced from the gasification facility will feed the combustion turbine generators, designed to generate the maximum electric power. Low sulfur diesel will be used as the backup fuel for the gas turbines. Heat recovery steam generators (HRSG) will be used to recover heat from the combustion turbine exhaust gas to produce high-pressure steam. The HRSG's will have supplemental duct firing with natural gas to provide quick backup steam response in the event one CT/HRSG goes down. Most of the high-pressure steam from the HRSG's will feed the existing power plant steam turbines to generate additional electric power and the 600 psig let down steam which is exported to the refinery. In addition, lower pressure (175 psig) steam will be generated in the quench/cooling section of the gasification unit, and exported to the refinery as well. A provision has been included to feed syngas, generated in excess of that required for the combustion turbines, as fuel for existing Power Plant Boiler No 3 to supplement steam production from the new HRSG's.

**TEXACO GASIFICATION SYSTEM**

*Coke Handling and Preparation*

2,100 tons per day of coke and fluxant from existing coke storage silos are conveyed to new dual train grinding mills. The grinding mills are fed coke, fluxant, recycle condensate, slag & fines water, and slurry recycle. Each grinding mill is a ball mill designed to reduce the feed coke to the design particle size distribution and produce design coke slurry.

From the grinding mills, coke slurry is collected in each of the mill discharge tanks and is kept in suspension by the mill discharge tank agitators. The mill discharge tank pumps transfer the slurry to the slurry run tanks through the slurry feed diverter. The slurry feed diverter allows either grinding train to feed either gasification train. The slurry run tanks are equipped with agitators to keep the slurry in suspension.
Gasification

The slurry feed pump takes suction from the slurry run tank and the discharge is sent to the feed injector of the Texaco gasifier. Oxygen from the Air Separation Unit is vented during preparation for start-up and is sent to the feed injector during normal operation. The air separation plant supplies 2,100 tons of 99 percent purity oxygen per day to the gasifiers.

The gasifier reaction zone is refractory lined and is designed to operate at high temperatures and pressures. The coke slurry and the oxygen feeds react in the gasifier at about 1,000 psig and at a high temperature (in excess of 2500 F) to produce syngas, consisting primarily of hydrogen and carbon monoxide, with lesser amounts of water vapor and carbon dioxide, and small amounts of hydrogen sulfide, carbonyl sulfide, methane, argon, and nitrogen. The heat in the gasifier liquefies coke ash and fluxant. Hot syngas and molten solids from the reactor flow downward into a water filled quench chamber where the syngas is cooled and the solids solidify. Raw syngas then flows to the syngas scrubber for removal of entrained solids. The solidified solids collect in the water sump at the bottom of the gasifier and are removed periodically, using a lock hopper system.

Solids collected in the quench gasifier water sump are removed by gravity and forced circulation of water from the lockhopper circulating pump. Fine material, which does not settle as easily, is removed in the gasification blowdown and goes to the vacuum flash drum by way of the syngas scrubber.

Syngas Scrubbing

The water/syngas mixture enters the syngas scrubber and is directed downwards by a dip tube into a water sump at the bottom of the syngas scrubber. Most of the solids are separated from the syngas at the bottom of the dip tube as the syngas goes upwards through the water. From the overhead of the syngas scrubber, the syngas enters the low temperature gas cooling section for further cooling.

The water removed from the syngas scrubber contains all the solids which were not removed in the quench gasifier water sump. In order to limit the amount of solids recycled to the quench chamber, a continuous blowdown stream is removed from the bottom of the syngas scrubber. The blowdown is sent to the vacuum flash drum in the black water flash section. The circulating scrubbing water is pumped by the syngas scrubber circulating pumps to the quench gasifier.

Slag Handling

The Slag Handling System removes solids from the gasification process equipment. These solids consist of a small amount of unconverted carbon and essentially all of the metals contained in the feed coke. These solids are in the form of a glass which fully encapsulates these metals. Solids exit the bottom of the Gasifier in a circulating water stream from the Lockhopper System. Solids enter the Lockhopper through an automatic valve. The Lockhopper dump cycle is controlled by valve sequencing. Slag from the Gasifiers is dumped to a Slag Pad which is divided into two sections; one for dumping and the other for draining and drying. A slag diverter is used to direct
the flow of slag water to the side being used for dumping. The solids are then removed from the
drying side by front end loader and transported to an industrial landfill.

**Low Temperature Gas Cooling**

Hot, particulate-free syngas from the scrubber is partially cooled in the medium pressure (MP) steam generator by producing 175-psig steam. The raw syngas is further cooled in the LP (50 psig) steam generator. The condensate in the syngas is removed in the steam generator knock out drum. The process condensate pump transfers process condensate to the syngas scrubber and the quench gasifier exit.

The syngas from the steam generator KO drum overhead is cooled in the steam condensate heater followed by the trim cooler. Condensate in the cooled syngas is removed in the trim cooler KO drum before routing the syngas to the Acid Gas Removal (AGR) section. Cooled process condensate from the trim cooler KO drum is recycled to the steam generator KO drum to help quench the syngas and reheat the condensate.

**Acid Gas Removal**

The Acid Gas Removal train is located adjacent to the gasification plot and feeds acid gas to the refinery sulfur plants. The AGR is comprised of an Acid Gas Absorber and Stripper. Raw syngas which has been cooled to 100°F and reduced in pressure from 1,000 psig to 330 psig flows to the Absorber. The syngas is counter-currently contacted with lean solvent in the Acid Gas Absorber. Acting as a weak base, the solvent absorbs acid gases such as a small amount of CO₂ and nearly all of the hydrogen sulfide (H₂S).

Rich solvent (solvent containing absorbed acid gases) flows from the bottom of the Acid Gas Absorber. The rich solvent is stripped of acid gases in the AGR Stripper through heat provided by low-pressure steam in the AGR Stripper Reboilers. Lean solvent exits the bottom of the AGR stripper as required to meet the flow requirements of the Acid Gas Absorber.

The AGR Solvent Storage Tank, a gas-blanketed, cone-roofed vessel, serves as a reservoir for fresh makeup Solvent to the circulating Solvent system. It also serves as the pumpout reservoir when the AGR is shut down.

**Combustion Turbines**

The plant utilizes two GE Frame 6FA Combustion Turbines, which are designed to fire pre-heated syngas or low sulfur diesel from the refinery (backup fuel only). Each combustion turbine is equipped with a dual fuel combustion system with separate nozzles for syngas and low sulfur diesel, and each is rated at 90 MW. Diluent nitrogen and/or steam are supplied to each combustor through a separate manifold. The nitrogen is routed from the Air Separation Unit (ASU) and serves to reduce NOₓ and improve the overall cycle efficiency. When the ASU or Gasifier are down, the combustion turbine operates on low sulfur diesel and requires steam for NOₓ control.
**Heat Recovery Steam Generators**

The two heat recovery steam generators (HRSG) are designed to utilize the exhaust heat from each turbine to generate steam for refinery use and power production in existing steam turbines. The HRSGs are one-pressure level, natural circulation design, and generate high pressure (HP) superheated steam which is sent to the existing power plant. The net power produced from the combined cycle plant is 120 MW since the ASU utilizes a large amount of the power generated.

High Pressure boiler feed water from the refinery is heated in the HRSG high-pressure economizer and fed to the evaporator drum. The feedwater flow control valve upstream of the evaporator drum controls the feedwater flow into the drum. Hot boiler feed water is used to attemperate the superheated high pressure steam and is also returned to the power plant.

The water in the HP drum circulates through the evaporator tubes where it is heated by the gas turbine exhaust gas to produce saturated steam in the HP drum. The water in the HP evaporator circulates naturally due to its difference in density. The steam then exits the HP drum after passing through the moisture separator. The dry steam from the HP drum flows through two HP superheater tube bundles where the steam absorbs additional heat from the highest temperature exhaust gas. Supplemental duct firing with natural gas is available to provide additional steam. The steam is attemperated with hot boiler feed water between the two HP superheater tube bundles. The superheated steam feeds the high-pressure steam header for export to the power plant for additional power generation. Small quantities are sent to the gasification block and to the Combustion Turbine when required.
List of Attachments:

- Figure 1 Block Flow Diagram
- Photograph of Repowering Site
- Photograph of Air Separation Unit
- Photograph of Combustion Turbines
- Photograph of Electrical Switchyard