Crude Heater (191-H-1) NOx Reduction Project

A refinery has a Crude Heater (191-H-1) in its Atmospheric Vacuum Unit AVU-191. The heater was built in 1969 and designed for 160,000 BPD at a total heat duty of 490.7 MMBtu/hr. The heater was later revamped to process 178,500 BPD of crude and 31,500 BPD of slip stream at total heat duty of 612.4 MMBtu/hr.

Furnace Improvements Services (FIS) was approached to modify the existing Crude Heater (191-H-1) to enable it to be retrofitted with a selective Catalytic Reduction Unit (SCR) to reduce NOx emissions to less than 0.010 lb/MMBtu. A new SCR and Waste Heat Recovery (WHR) are installed to accomplish these changes. FIS also performed the CFD analysis to ensure there is proper mixing of Ammonia with flue gases in the SCR unit and there is uniform distribution of flue gases over the catalyst bed.

In the proposed option, FIS designed the heater for 260,000 BPD at a firing rate of 727 MMBtu/hr (LHV). Crude feed to 191-H-1 is split into two streams: A hot stream (main crude charge) at 215,000 BPD, 456°F and a cold stream (slip crude stream) at 45,000 BPD, 240°F. The total absorbed heat duty of the Crude Heater is 672.2 MMBtu/hr. The WHR section is designed to reduce the flue gas temperature to 300°F as opposed to the current 350°F to 385°F.

FIS' scope included providing engineering services, designing equipment and providing materials needed to modify the existing Crude Heater and auxiliary equipments. FIS' scope included the supply of a new waste heat recovery unit, modification the existing

heater convection, and upgrade of the FD and ID Fans. The new waste heat recovery is installed and connected to the new SCR and existing Crude Heater.

Crude Heater Revamp

The existing slip crude stream in the convection section has 24 rows. Fourteen rows are removed from service to achieve the required temperature window for SCR operation. The convection section is divided into two sections: lower and upper, by installing a new horizontal baffle plate. The plate acts as a barrier and forces the flue gases to exit from the lower section to the SCR, WHR, and then return to the upper section. The blanking plate is a new concept and it is being done for the first time. This design saved our client between $5- $6 Million.

Waste Heat Recovery Unit

The Crude Heater (191-H-1) is supplemented with an outboard WHR unit. The unit is located downstream of the SCR unit. The heat transfer area was removed from the heater convection section to achieve the required temperature window. This was done to avoid condensation recovered in the WHR. The design slip crude flow rate through the WHR will be 45,000 BPD (560,000 lb/hr). The outboard WHR unit will heat slip the crude stream from 240°F to 470°F. The calculated pressure drop across the WHR is 46.9 psig. The flue gas enters the WHR at a temperature of 700°F and leaves at 300°F.

Soot Blowers

Twenty-eight electric-motor driven soot blowers are provided in the WHR unit. The soot blowers are installed in the WHR to clean the any ammonium bisulfate deposits resulting from the reaction of excess NH_3 and SO_3 from the surfaces.

FD & ID Fans

The FD fans are upgraded to increase capacity and reduce the noise across the combustion systems. The fans are retrofitted with a new impeller, shaft, inlet vanes, inlet cones to match new rotor, an inlet damper, and silencer and intake hood. The motor is also being upgraded from a 400 HP to 500 HP motor. Similarly the four ID fans and motors are upgraded.

Case Studies (FIS-254)

Dampers

There is a total of 16 dampers that are provided in the Crude Heater. All the 16 dampers were replaced because they were not in working condition. The new dampers were installed at the existing damper locations.

Finger Ducts & Expansion Joints

New duct work is installed to the north side of the Crude Heater. The hot flue gas ducting is designed to optimally fit starting from the heater to the new SCR and from SCR to WHR. The hot flue gas enters the duct, passes through the Ammonia Injection Grid (AIG), and enters the SCR. Expansion joints were also provided on each duct. Cold flue gas ducting was designed to fully integrate with the WHR system with the existing convection box (below the existing ID fans). The six cold flue gas ducts tie into the heater above the blanking plate.

Ammonia Injection Grid

The new AIG was installed in the hot flue gas finger ducts. The AIG is located 10 feet away from the heater casing. Ammonia is injected from the bottom through these pipes in the same direction as flue gas flow. NOx in the flue gases reacts with Ammonia over a catalyst to form Nitrogen and water vapor.

Description	Before Revamp	After Revamp
Total Heat Duty, MMbtu/Hr	612.4	672.2
Heater Efficiency (LHV), %	91	92.4
Stack Temperature, °F	350 – 385	300
NOx, lb/MMbtu		< 0.01 lb/MMBtu

The total cost of the project for design, engineering, fabrication and supply is $7 Million. Erection has been completed and the heater commissioned in February 2009.