Lifting a regenerator head into place at ExxonMobil refinery in Billings, Montana

Optimizing FCCUs: Fast Track Projects for Today's Refineries

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In the 1970s and 1980s, a typical refinery maintenance outage lasted anywhere from 30–45 days and occurred every two or three years. Today, many refineries can run twice as long before they need to shut down for maintenance and the typical outage lasts about half the time. One of the most important processes in a refinery is the fluid catalytic cracking process. This process, which is used in refineries to break down heavy oils into lighter products, allows owners to meet the demand for higher-quality, higher-octane products. Because of the vital role of this process, refineries that have Fluid Catalytic Cracking Units (FCCU's) generally choose to revamp or upgrade these units during a regularly scheduled maintenance shutdown. FCCU maintenance projects are driven by operational needs, such as the need to increase the capacity of the FCCU, handle a change in the stream fed into the FCCU, or improve reliability and extend the life cycle of the FCCU. These projects can range from relatively minor repair projects to major revamps that result in, essentially, the installation of a brand new unit.

Historically, significant FCCU advances that provide timely returns on investment are produced about every five to seven years for FCCUs. This technology and/or process breakthrough timeframe has generated a cyclical approach to FCCU upgrades, repairs and replacements that gives owners the opportunity to plan ahead for future projects, potentially reducing the overall total investment. In planning current and future projects, owners seek solutions that will help them reduce scheduled outages, increase reliability and maintain safe operations, all while enhancing the revenue producing capability of the refinery.

FCCU revamp or upgrade projects have several variables that can greatly impact the budget and the schedule of the project. These include: contracting strategies; construction methodologies; and sourcing options.

The choices made in each of these areas can provide the framework for a successful FCCU upgrade or repair project.

Contracting Strategies

In determining the best contracting strategy for the project, owners can select individual contractors for each project component, such as process engineering, mechanical design and construction, or they can select a contractor that will undertake the entire project, providing a single point of accountability. Selecting a contractor for each project component gives the owner more control of the project and the ability to allocate resources as needed. But this approach is very demanding on refinery management, especially during the planning phase. On the other hand, a contractor that can provide a single point of accountability and self-perform all or most of the work can greatly decrease the additional load the project will place on refinery management. A contractor that provides a single point of accountability can also be a valuable partner to the owner during the planning of the project.

Regardless of whether the owner selects a contractor to undertake the entire project or decides to manage the project with internal resources, the owner and contractor(s) together can determine the lowest overall cost solution for the current project and potentially reduce costs on future projects, as well. For example, when designing a new FCCU, creating space in the overall footprint so that heavy lifting equipment can be brought in for future maintenance projects can reduce the overall project cost of maintenance projects. Some owners have even

opted to leave in place the foundation for the crane, removing this cost from future outages. Likewise, building super slabs to support FCCU's and improving the sub-surface soils to accommodate large cranes is an up-front investment that can reduce future project costs.

Good contractors often work with refineries to develop the optimal plan to revamp or upgrade their FCCUs, using industry best practices such as those outlined by the Construction Industry Institute (CII). CII is a 90+-member organization that brings together owners, contractors and suppliers from the public and private sectors to research ways to improve the planning and execution of major construction projects. The institute emphasizes the need for "front-end loading" and has conducted studies that show, time and again, that changes made at the front end of a project entail significantly lower costs than the same changes made later in a project. It is in these early planning stages that the owner and contractor have the greatest opportunity to impact the final budget and schedule. By combining their knowledge of the business, technology and product, they can jointly plan the project to optimize the performance of the FCCU and its impact on the overall operations of the refinery. This is true regardless of whether the FCCU is a new unit being installed into the refinery or a project that will revamp or upgrade the FCCU already in place. Clearly, there is a real benefit in contracting early.

Other contracting strategies include risk management alternatives, such as lump-sum turnkey (LSTK) awards, in place of the more traditional cost-reimbursable payment methodologies. However, in the case of a revamp or upgrade, it is generally not possible to anticipate everything that will be required for the project until the refinery is shut down and the unit is entered. For this reason, these projects are usually performed on a cost-reimbursable basis and the best contractor choice is flexible, resourceful and skilled at adapting to changing needs without significantly impacting the schedule. While the front-end planning is also frequently bid on a cost-reimbursable basis, the engineering, procurement, fabrication and other work performed prior to the plant shutdown can be contracted on a LSTK basis to companies that have the resources and experience to handle these projects and are willing to take on the associated risks.

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Construction Methodologies

Nowhere are the savings—in terms of both budget and schedule—more critical than in the construction phase of the project. A refinery that is earning in excess of $500,000 a day does not want to shut down its operations for a single hour longer than necessary. Because in most cases major portions of the refinery must be shut down for some period of time to complete these projects, they are generally handled as turnaround projects.

The mechanical portion of a turnaround project that took an average of 45 days in the 1980s can generally be completed in less than 30 days today. Time has been shaved from the schedule in several ways:

- Planning: Contractors with experience and skill at performing turnaround projects have learned to plan these projects by the hour. These projects frequently include second and third shifts to keep the project on as fast a track as possible. The hour-by-hour plan includes the work performed on all shifts.
- Pre-turnaround work: With experience, contractors are able to perform more and more of the ancillary work prior to the turnaround, thus shortening the length of the turnaround.
- Fabrication and modularization: In most cases, some (or all) of the FCCU can be fabricated in a shop environment and transported to the site for installation, including pump packages, steam stations, control panels and electrical grids, as well as regenerators and reactors. These prefabricated components are designed to be quickly lifted into place using the site crews and cranes.
- Replacement parts: Sometimes, the most cost-effective approach to a revamp is to prefabricate a large piece of equipment and replace it in its entirety, even if the shell encasing the equipment is still good. The cost of the carbon steel encasing the part may be less expensive to replace than the downtime associated with removing the equipment from the shell and replacing it with a new part.

Owners strive to find a contractor who has both the engineering and the construction expertise to find the construction methodologies that will provide the most cost effective solutions possible.

Sourcing Options

A final key to a successful project is having access to sourcing options that provide needed resources at critical phases of the project. Owning or being able to obtain heavy lifting and rigging equipment is vital. Individual elements of an FCCU can weigh as much as 200-400 tons each. Cranes that lift loads ranging from 400 to as much as 1,000 tons are available to lift these components into place. These cranes make it possible to do more of the work in the pre-turnaround phase of the project than previously possible by allowing for the pre-fabrication of very large components.

Access to sourcing options can also facilitate the transportation of components that have been pre-fabricated in a shop environment. Lifting large pieces of equipment that weigh 380 tons and have a radius of 280 feet provide considerable logistical challenges for the contractor. Since each project is unique,

the optimal solution for one project may be very different from that of another. The size, height and weight of the component must be considered along with the road, rail and waterways that connect the shop to the refinery. When both the refinery and the shop are located near a port, the best option is usually to transport the component via barge. When barge is not an option, rail and road options must be considered along with permitting requirements and load and height limits. Bridges, underpasses and narrow roadways must be carefully evaluated. One option that should not be overlooked when transportation choices are limited is the option to set up a shop near the refinery. The advantages of pre-fabricating the components in the pre-turnaround phase can still be realized and the cost reduction in shipping the components can help offset the cost of setting up the shop.

Case Studies

The following case studies are illustrative of trends in FCCU upgrade and repair projects over the past decade. They also demonstrate how each project has unique characteristics that require flexibility, resourcefulness and innovative solutions on the part of the contractor.

In 1996, owners of a 250,000 b/d refinery in southern California wanted to install a new reactor and revamp the existing regenerator to increase output from the refinery. They scheduled 23 days to complete the mechanical portion of the project.

CB&I developed a plan to meet the schedule through various innovative technical solutions. The plan called for assembling both the reactor and the regenerator in large pieces, each of which would then be lifted into place and welded. To provide the extensive amount of post-weld heat treatment required, a temporary furnace was constructed at the site. A new bottom cone for the regenerator was pre-fabricated with air grids attached to simplify activities during the shutdown. All hydrotesting of the reactor was completed well in advance of the shutdown, along with all pre-assembly of the regenerator components.

All the scheduled work for this project was completed on time and an additional component that was added to the scope during the shutdown was also completed without adding any time to the schedule. This additional component was a small clad tower (6 feet by 50 feet) within the unit that the refinery's inspectors found had extensive cracking and needed to be replaced. A replacement vessel was designed, the material procured, the replacement vessel was then fabricated and erected during a 19-day period that allowed it to be completed within the shutdown schedule.

Four of the lifts exceeded 200 tons and the heaviest weighed 290 tons. An S-70 stiffleg derrick, with a 500-ton lifting capacity, was located on a 200-foot high tower to perform these lifts, which enabled an important roadway in the immediate area to remain open for emergency vehicles.

The shutdown for this project was scheduled to last 23 days, but the work was completed in just 20 days with no recordable injuries.

In 1998 and 1999, Exxon wanted to upgrade two FCCUs (PCLA-2 and PCLA-3). This project entailed replacing both reactors, as well as making modifications to the structure, transfer lines and various other components. In both cases, the project was complicated by the placement of the reactors under the regenerators. Further complicating the PCLA-3 project, nearby pipe racks and other components crowded the unit, leaving no suitable area in which to locate both a crane and an assembly area for the reactor.

CB&I developed a plan to assemble the vessels within reach of the cranes. The vessels would then be cut into pieces that the crane could lift into place. The PCLA-3 project was constructed on a temporary foundation within reach of an S-70 stiffleg derrick.

This derrick had been used on a previous project and the foundations were left in place with anchor bolts protected so they were available for re-use on this project. After the assembled vessel was hydrostatically tested and code stamped, it was cut into three pieces, the refractory lining was installed and the internal components were added. Each of the three sections weighed approximately 250 tons. The vessel, which was approximately 7 feet larger in diameter than the one being replaced, was lifted into place starting with the lowest section, and the circumferential seams were welded to complete the reassembly process.

The PCLA-2 project was completed using a Lampson LTL-1200 crane, which had also been used on a previous project. Once again, the foundation for the crane had been left in place, making it available to re-use with this project. After the vessel was tested and code stamped, it was cut into two major sections, plus a smaller third section that included the skirt. Because of the heavy lifting capacity of the crane, the regenerator was removed, the reactor installed and then the regenerator replaced. Altogether, there were five lifts over 300 tons, with two reaching 380 tons and a working radius of 280 feet.

Both projects were completed on time and within budget.

Looking Ahead

As contractors continue to work with owners to seek innovative approaches to FCCU repair and upgrade projects, the current trend of making the outages shorter and the periods between outages longer is likely to continue. Advances in FCCU technology have increased the reliability of the units, while the ability of contractors to exchange older units for new ones makes upgrade projects a sound investment. Keeping safety at the forefront of these projects remains a priority, as both contractor and owner seek the optimal solution for meeting the long-term needs of the refinery. ●