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Integration design and benefits of petrochemical complex leveraging on existing refinery

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Abstract

The main objective of this study is to identify the inherent benefits associated with integrating a new petrochemical facility with existing refinery. Petrochemical complexes heavily rely on feedstocks like naphtha and refinery gases, which are frequently produced in oil refineries, ensuring a reliable supply of essential raw materials. Integration between the petrochemical facility and refinery becomes necessary due to their downstream position relative to each other. Moreover, integration allows for leveraging operational synergies, sharing resources, infrastructure, and expertise to optimize operations and enhance productivity. Refineries known for their advanced technologies, and production of high-quality products from crude oil.

Keywords: Engineering; Petrochemical; Refinery; Integration

1. Introduction

Objective

Project Integration Area always houses all pipelines and equipment required for refinery and petrochemical products to exchange streams. Each interconnecting pipe is part of a more extensive system that includes upstream circuits that feed into the line (source) and downstream circuits that receive it (destination). The entire system's design is considered, including sources, destinations, and interconnecting systems. This option ensures system integrity and the proper design of each component. Refinery and petrochemical items are handled and distributed by a refinery Integration Unit. The petrochemical complex feedstocks are primarily used to feed Cracker unit and maximize downstream derivatives output. A major feedstock of the Cracker are streams from the refinery, as well as other feeds such as (ethane, natural gasoline).

The primary objective is to accommodate the scope mentioned above within the potential facilities and make it possible for the refinery system to manage the petrochemical services in the system and vice versa. This involves the exploitation of existing infrastructure, plot area for services, and tie-in connections. The existing facility must accommodate the new requirements into the existing systems in all aspects, including the database, standards and specifications, space utilization, synchronization of the instrumentation, and electrical requirements. Due to the nature of the existing facility, the current active systems cannot be altered as much and the new system must accommodate any modifications to the existing facility.

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Figure 1 Refinery Plant

Figure 2 Petrochemical Plant

2. Evaluation involved in an integration of existing plant into a new plant:

Converting an existing plant into an integrating facility involves careful planning, assessment, and decision-making. Here are some key considerations and steps to think about:

- **Feasibility study:** Evaluate the feasibility of integrating the existing plant into a new facility. Assess factors such as the condition of the plant, its infrastructure, location, available resources, and market conditions. Need alignments with the market needs and business goals.
- **Design and engineering:** Develop a comprehensive design and engineering plan for the new plant. Consider the required modifications, upgrades, or expansions needed to transform the existing facility into the desired integrated plant. Ensure compliance with safety, environmental, and regulatory requirements.
- **Technology and equipment:** Evaluate the technology and equipment needed for the new plant. Determine if the existing plant's technology and equipment can be repurposed or if new investments are necessary. Consider factors such as efficiency, productivity, scalability, and sustainability.
- **Cost analysis:** Conduct a cost analysis to estimate the expenses involved in integrating the existing plant into a new facility. Consider the costs of modifications, equipment purchases, labor, permits, and any potential downtime or production interruptions during the conversion process.
- **Risk assessment and mitigation:** Identify potential risks and challenges associated with the conversion process. Develop strategies to mitigate these risks and ensure safety protocols are in place.
- **Stakeholder engagement:** Engage with relevant stakeholders, including employees, local communities, suppliers, and regulatory directives. Communicate the purpose, benefits, and progress of the conversion process to maintain transparency and build support.
- **Continuous improvement:** Implement a system for continuous improvement and monitoring of the new plant's performance. Regularly assess efficiency, productivity, and customer satisfaction to identify areas for optimization and refinement.

By considering these steps above and factors, we can navigate the conversion process successfully and maximize the potential of the new plant.

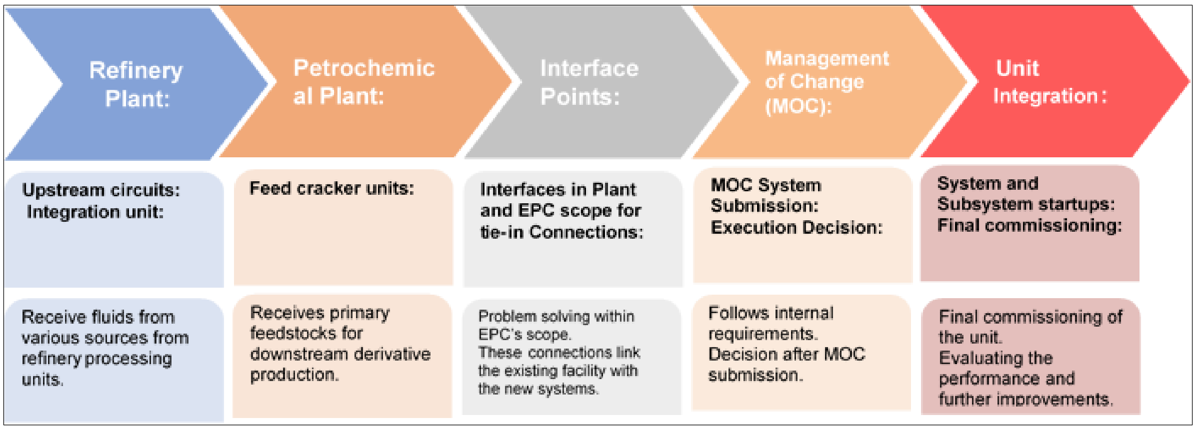

Figure 3 Conversion Process

Here's a summarized version focusing on the flow from upstream refinery streams to petrochemical products:

- Utilize upstream refinery streams as feedstock.
- Integrate refinery and petrochemical processes.
- Process streams through petrochemical units
- Convert streams into intermediate chemicals.
- Transform intermediate chemicals into final petrochemical products.

Figure 4 Plastic Bagging

Figure 5 Product Sample

Figure 6 Stacked Pallets

3. Process Engineering Upfront

In mega project execution philosophy, based on the concept of integrating the existing refinery plant with the new petrochemical plant, the professional and sequential approach to engineering and design must be carefully sourced. In such an integration project the process design is the major pillar of system design used to finalize process requirements. This is due to the current facility as the accessible data is dispersed and must be collected and categorized to satisfy the requirements of the project, which necessitates considerable time prior to initiating the design process. This can be accomplished with the aid of the plant's operations and engineering departments. Also, the integrity of the existing facility must be confirmed in conjunction with the introduction of new system needs. This entails confirming and validating all steam, air water, and nitrogen-related parameters, as well as evaluating the cooling water demand. The full flare network system is to be revalidated by conducting a comprehensive network study to satisfy the need for additional infusion and the existing system's capacity to manage this increased demand into the existing network and ultimately function to the plant's requirements. In addition, to elaborate on the process requirements, the tie-in connections of each system, including process and utilities with subsystems, must be studied, and identified at the earliest stage of the project to mitigate the requirements of shutdown and non-shutdown tie-ins to accommodate space reservation of each tie-in and line route spacing. The method must also identify the number of new types of equipment with each system to be introduced to deal with plot space approval and reservation in the existing congested facility in accordance with the project design specifications. Significant process work is necessary to identify the electrical and instrument requirements for the refinery's current facility. The sequential engineering work or the execution of the process engineering work in advance will allow the other disciplines to advance without major rework and allow for a seamless progression.

The importance and benefits of integration between the refinery and petrochemical plant:

- **Feedstock Utilization:** Integration enables efficient use of refinery outputs as feedstock for the petrochemical plant.
- **Cost Optimization:** Shared infrastructure and resources lead to cost savings.
- **Process Efficiency:** Integration streamlines production processes, reducing energy consumption, and waste generation.
- **Product Diversification:** Integration expands the range of products that can be produced.
- **Operational Flexibility:** The integrated facility can respond quickly to market demands.
- **Environmental Impact:** Integration offers opportunities for environmental improvements.
- **Knowledge and Expertise Sharing:** Collaboration between the refinery and petrochemical plant promotes innovation and operational best practices.

4. Interfaces and Tie-In Details

As the project requires a connection to the existing facility, this must be accomplished by connecting to the existing pipes. A tie-in connection must be established before constructing the actual systems to carry out this task. The tie-ins may be performed during the shutdown or non-shutdown period, but they must be coordinated with the plant's operations and their planned turnaround timeline. Accordingly, based on the agreement and approval, an appropriate sequential site visit is to be conducted, and the report is to be submitted, approved, and formally documented through the proper channels with the signatory of the higher authorities. Once the approval has been granted, it must be reserved on site with the required markings. The sample must be measured on site, and the approval document must be provided to the plant for record-keeping purposes to prevent another contractor from performing design or construction operations at the designated location.

To carry out the project's objectives at a refinery facility, the in-house system of Management of Change must be adhered to. Based on this, the MOC system submission must be carried out following the refinery internal requirements, which include the proper MOC submittal with all the pertinent details, including the complete design package, the materials, the vendor details, the welding testing requirements, and the relevant inspection particulars associated with each MOC system defined. Once the measures mentioned above have been taken, the decision on whether to factor the MOC into execution is made.

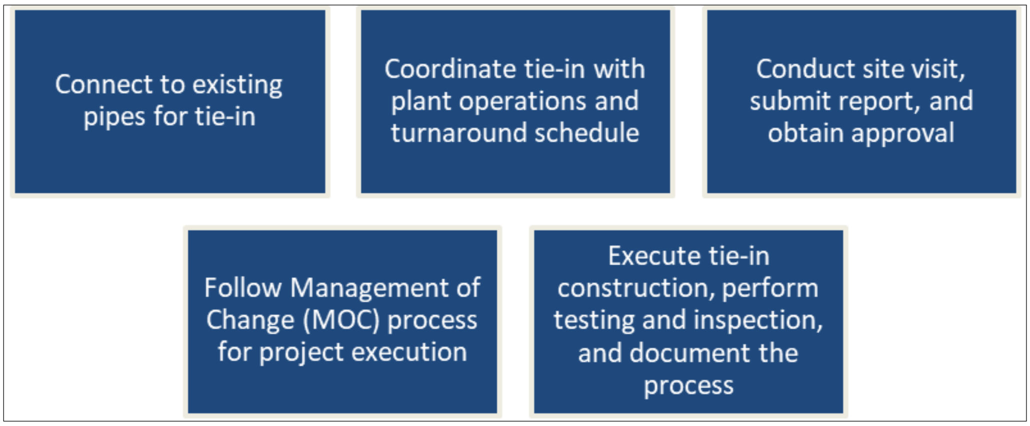

Figure 6 Sample Workflow

5. Piping Material Issues

In mega projects involving the construction of oil and gas facilities, it is common to have multiple engineering, procurement, and construction (EPC) contractors working simultaneously to meet tight deadlines and milestones. Each contractor typically employs their own set of tools and methodologies to accommodate the project's time constraints.

Despite the existence of industry-standard codes, specifications, and requirements, discrepancies can arise in the data provided by different EPC contractors. This particularly applies to piping materials used in the construction of the facilities. When the project nears completion, each contractor delivers various documents related to piping, such as piping service class, piping class summary, piping classes, and piping material specifications, along with the 3D database.

The challenge arises from the fact that material selection for the same pipe class may vary among contractors based on their specific project needs and preferences. This inconsistency in material selection can lead to compatibility issues when integrating the new petrochemical plant with the existing refinery.

However, given the need for collaboration and adherence to the existing refinery system, which cannot be modified, it becomes essential to address these piping material issues. The integration process must ensure that the new system has the necessary flexibility and adaptability to meet the requirements of the existing refinery infrastructure. This involves carefully assessing the compatibility of piping materials, reconciling any inconsistencies, and ensuring seamless integration between the new and existing systems.

By effectively managing the piping material issues and promoting compatibility between the different components, the integrated facility can operate smoothly, maintain system integrity, and achieve the desired operational efficiency between the refinery and petrochemical plant.

6. Conclusion and recommendation

- The integration of new petrochemical facilities with existing refineries offers numerous benefits, including cost savings, process efficiency, product diversification, and environmental improvements. Future projects should prioritize this integration from the early stages to maximize these advantages.
- A professional and sequential engineering approach is recommended, focusing on system design, compatibility of piping materials, and adherence to existing infrastructure and specifications. Thorough studies and documentation, along with effective management of change processes, are essential for successful integration.
- Resolving piping material issues is crucial to ensure seamless integration, system integrity, and operational efficiency between the refinery and petrochemical plant. Projects should aim for optimal utilization of existing resources and foster collaboration to promote knowledge sharing and innovation.
- Appropriate external and internal interfaces must be discovered, and approval of the same must be obtained as soon as feasible to minimize delays in the early phases of the integration project's execution.
- The proper boundary of the project scope necessitates identifying the precise external and internal interface points to ensure that the appropriate standards and specifications for the applicable projects are used during the design and construction phases.
- The proper execution of the new tie-ins and the approval of the same in terms of plot space and tie-in reservation, as well as the reservation of line space, must be done in a timely way based on the current situations and issues, as well as the available data in the existing plants.
- Organization rules must be devised based on the turnaround requirements for establishing the shutdown and non-shutdown items sequence. Consequently, management of change approval with the formal submission in-house system must be filed for sequential approval for the execution of each MOC, depending on the turnaround time.
- The availability of the necessary materials must be ensured before construction. The material requisition with technical requirements and MR approval processes must be resolved in advance, particularly for the crucial and long-lead goods.
- To prevent negligence during the design and implementation phases of a project, the definition of the specifications and standards must be formalized and distributed to all involved parties.
- The correct design phase must be followed to resolve data integration concerns, particularly for brownfield projects with integration problems.
- The reviewer assigned by the plant representative to assist with the integration project should be assigned at the onset of the project to facilitate clear direction of data utilization from the existing facility, the availability of existing and updated brownfield data, and the prompt delivery of responses to TQs and any action items.

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